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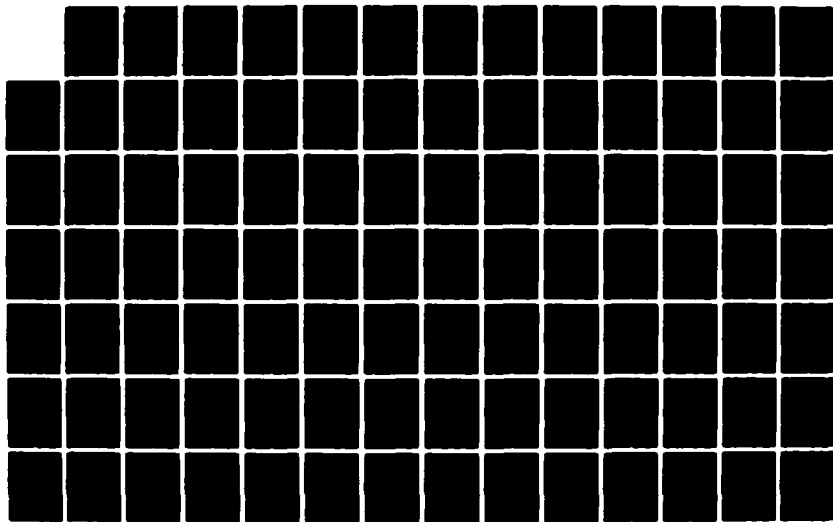
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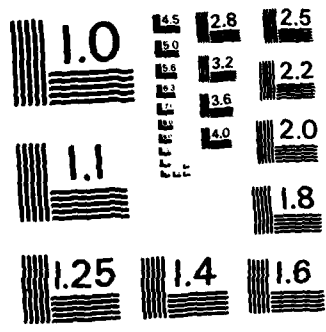
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# SOFTWARE CATALOG

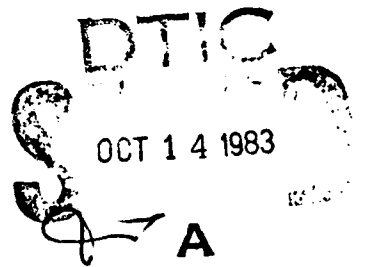
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## SPARSE MATRIX SYMPOSIUM 1982

Fairfield Glade, Tennessee

October 24-27, 1982



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# **SPARSE MATRIX SOFTWARE CATALOG**

## **Sparse Matrix Symposium 1982**

Fairfield Glade, Tennessee

October 24-27, 1982

Michael T. Heath, Editor

### **SPONSORS**

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## Preface

This software catalog was prepared in conjunction with the Sparse Matrix Symposium in Fairfield Glade, Tennessee, October 25-27, 1982. It is intended to provide information on computer software for sparse matrix problems which should be useful to software developers and consumers alike. The information provided includes the problem domain to which the software is applicable, the method of solution, language and portability details, references to documentation, and a contact for further information or acquiring the software. This information is reported by means of a form which was filled out by each contributor for each item of software.

Contributions to the software catalog were solicited as part of the general announcement and call for papers for the Symposium which appeared in the official newsletters and other publications of several professional societies in mathematics, computer science, and operations research. There was also a mass mailing of general Symposium announcements to about 375 persons (mostly numerical analysts, applied mathematicians and computer scientists, plus a few engineers), and an additional mailing to about 80 persons which specifically solicited software catalog contributions. These efforts resulted in the submission of about 120 software forms. All submissions were accepted for inclusion in the catalog.

Thus, the catalog is about as complete as voluntary contributions can make it. In addition to containing virtually all of the software already well known to the sparse matrix community, many lesser-known packages are brought to light in these pages. The main area of sparse matrix software which is seriously underrepresented in the catalog is software for specific applications, such as *structural analysis, in which modules which might have much wider applicability are buried within a much larger, special purpose package.* We regret such omissions, but to have reached the practitioners in each of the diverse applications areas would have enormously expanded the scope of our publicity campaign and mailing lists.

The software reporting form which was sent to potential contributors was accompanied by a cover letter (which is reproduced here as Appendix A) and instructions for completing the form (Appendix B). In addition, the contributor was asked to help in organizing the catalog by specifying the appropriate categories and key words as outlined in Appendix C. There is also an appendix describing the restrictions on use of codes from the Harwell Subroutine Library, which its authors felt did not fit conveniently within the small space allowed for that purpose on the reporting form. The catalog is organized by problem domain and methods of solution, so that closely related programs appear near each other. As an aid in locating software by name of package or author, alphabetical indices are provided at the back of the catalog.

Most of the software forms have been photographically reproduced, exactly as received from the contributor. A few have been retyped for improved legibility (generally, those forms which were filled out by hand in pencil or colored ink). The accuracy of the information provided is therefore totally dependent on the individual contributors. The organizers and sponsors of the Symposium make no guarantee as to the accuracy of the information contained herein or the usefulness or validity of the software reported. The inclusion of information on a given item of software is not to be construed as an endorsement of it. It should be emphasized that this catalog is in no sense a software distribution service: in order to obtain any of the software discussed, the individual distributors listed on the forms must be contacted.

It is hoped that this catalog will provide a valuable service to the research and development community in the sparse matrix field and will also prove helpful to potential users in locating appropriate sparse matrix software. Perhaps it will become the basis for future efforts at even more comprehensive cataloging of software in sparse matrices as well as other areas.

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- 1. Name of program or package:** ALGORITHM 408
- 2. Descriptive title:** A Sparse Matrix Package (Part I)
- 3. Problem domain:** (Elementary operations on general sparse matrices,  
e.g., addition, multiplication, transposition,  
**4. Method of solution:** extraction of rows.)
- 5. Programming language:** FORTRAN 66
- 6. Precision:** Single
- 7. Portability:** Good (IBM 360)
- 8. Other packages required:**
- 9. Mode of use:** Subroutines
- 10. Test or demonstration program available?**
- 11. Length of code in lines:** ~ 1500      **Percentage comments:** 30%
- 12. Special features:** —
- 13. Documentation and references:** Comm. ACM 14 (1971), 265-273  
**Detailed header comments?** ACM Trans. Math. Software 6 (1980), 456-457  
**User guide or manual, technical reports, papers, books:**
- 14. Approximate cost of obtaining software:** as per ACM TOMS rate
- 15. Restrictions on use:** —
- 16. Distributor:** ACM TOMS
- 17. Original source of software:**  
**Developer:** (See below)  
**Institution:**  
**Sponsor:**
- 18. For further information contact:**  
Professor J. M. McNamee  
Atkinson College, York University  
4700 Keele Street  
Downsview, Ontario, CANADA M3J 2R7



- 1. Name of program or package:** SPARSE
- 2. Descriptive title:** Transformations and manipulations of sparse matrices
- 3. Problem domain:** Linear algebra, arithmetic operations including I/O, transformations full matrices  $\rightarrow$  sparse matrices, transformations to NAG-routines Mark 5, 7
- 4. Method of solution:** Inversion of part of a matrix via SOR-iteration  
inversion of a lower triangular matrix
- 5. Programming language:** FORTRAN IV (FORTRAN 66)  
FORTRAN V (FORTRAN 77)
- 6. Precision:** Depending on the hardware of the machine
- 7. Portability:** PFORT-tested, special I/O in special modules
- 8. Other packages required:**
- 9. Mode of use:** Subroutine calls
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** **Percentage comments:** 20%
- 12. Special features:** If the user is not familiar with the sparse techniques he can give full vectors or matrices and they are transformed automatically. Automatic use of disks (I/O) when the fields for the target matrices of arithmetic operations are too small.
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - User guide at the moment only in German (70 pages)
    - Base: J. M. McNamee's Algorithm 408, Comm. ACM 14 (1971), 265-273
    - U. Harms et al, TOMS, Vol. 6, No. 3, September 1980
- 14. Approximate cost of obtaining software:** Noncommercial use: tape fee  
Commercial use: contact developer
- 15. Restrictions on use:** None
- 16. Distributor:** RRZN, Regionales Rechenzentrum für Niedersachsen,  
Wunstorfer Strasse 14  
D-3000 Hannover 91, West Germany
- 17. Original source of software:**
  - Developer:** J. McNamee, U. Harms
  - Institution:** RRZN
  - Sponsor:**
- 18. For further information contact:**
  - U. Harms
  - RRZN
  - Wunstorfer Strasse 14
  - D-3000 Hannover 91
  - West Germany

1. **Name of program or package:** RALAPACK
2. **Descriptive title:** Addition, multiplication, transposition, triangular factorization, backsubstitution, etc, with sparse matrices.
3. **Problem domain:** Real sparse matrices and vectors.
4. **Method of solution:** Sparse matrix techniques.
5. **Programming language:** FORTRAN IV.
6. **Precision:** Single.
7. **Portability:** IBM-360; IBM-370; VAX-11; CDC-6600; CDC-7600; XEROX-SIGMA-7.  
Easily portable to other machines.
8. **Other packages required:** None.
9. **Mode of use:** Callable subroutines.
10. **Test or demonstration program available?** No.
11. **Length of code in lines:** 388.                      **Percentage comments:** ---
12. **Special features:** None.
13. **Documentation and references:**  
    **Detailed header comments?** No.  
    **User guide or manual, technical reports, papers, books:**  
    The operation manual is provided with the program (present version is in Spanish).
14. **Approximate cost of obtaining software:** None. Write to liaison officer.
15. **Restrictions on use:** Only for research purposes.
16. **Distributor:** Liaison officer is: Sergio Pissanetzky, Centro Atómico Bariloche, 8400 - Bariloche, R.N., Argentina.
17. **Original source of software:**  
    **Developer:** Sergio Pissanetzky  
    **Institution:** Comisión Nacional de Energía Atómica  
    **Sponsor:** Comisión Nacional de Energía Atómica
18. **For further information contact:** ---

1. **Name of program or package:** SMULT
2. **Descriptive title:** Multiplies two sparse matrices together to form their sparse product
3. **Problem domain:** General sparse matrices
4. **Method of solution:** Unordered merge and ordered merge
5. **Programming language:** FORTRAN
6. **Precision:** Single and double precision
7. **Portability:** IBM 370 in FORTRAN
8. **Other packages required:** Can use HALFP
9. **Mode of use:** Callable subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 400 lines      **Percentage comments:** 50%
12. **Special features:** Compute the product in the number of nontrivial multiplications
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - Two Fast Algorithms for Sparse Matrices: Multiplication and Permuted Transposition, ACM TOMS, Vol. 4, September 1978, pp. 250-269
14. **Approximate cost of obtaining software:** See 18.
15. **Restrictions on use:** None
16. **Distributor:** Same as 18.
17. **Original source of software:**
  - Developer:** Fred G. Gustavson
  - Institution:** IBM Research
  - Sponsor:**
18. **For further information contact:**
  - Dr. Fred G. Gustavson 33-205
  - IBM T. J. Watson Research Center
  - P.O. Box 218
  - Yorktown Heights, New York 10598
  - Phone: (914) 945-1980

1. **Name of program or package:** PROD
2. **Descriptive title:** Obtain the product of two sparse matrices, or of a subset of the rows of ones times a subset of the columns of the second.
3. **Problem domain:** sparse matrices data management and operations
4. **Method of solution:** compares new indices of the first factor with column indices of the second.
5. **Programming language:** ANSI Standard Fortran
6. **Precision:** either
7. **Portability:** developed on a Cyber but very portable
8. **Other packages required:** none
9. **Mode of use:** callable subroutine
10. **Test or demonstration program available?** yes
11. **Length of code in lines:** 80                      **Percentage comments:** 40%
12. **Special features:** different options of storage use are available, depending on the size of the matrices
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:** none at the present time
14. **Approximate cost of obtaining software:** free
15. **Restrictions on use:** none
16. **Distributor:** same as 18
17. **Original source of software:**
  - Developer:** Daniel Szyld and Oleg Vishnepolsky
  - Institution:** Institute for Economic Analysis-New York University
  - Sponsor:**
18. **For further information contact:**
  - Daniel B. Szyld
  - Institute for Economic Analysis
  - New York University
  - 269 Mercer Street
  - New York, NY 10003
  - Phone (212) 598 3413

- 1. Name of program or package:** SPRSBLAS
- 2. Descriptive title:** Sparse vector operations on the CRAY-1.
- 3. Problem domain:** Gather, scatter, dot and saxpy for sparse vectors. Also contains single and complex BLAS.
- 4. Method of solution:** Standard algorithms optimized for CRAY-1, fastest available.
- 5. Programming language:** CRAY-1 Assembler Language (CAL).
- 6. Precision:** Single and complex.
- 7. Portability:** Not portable.
- 8. Other packages required:** These routines are a part of CRAYPACK (60 subroutines including BLAS, FFTS, sorting).
- 9. Mode of use:** FORTRAN-callable subroutines and functions.
- 10. Test or demonstration program available?** No
- 11. Length of code in lines:** 1000 lines      **Percentage comments:** 30%
- 12. Special features:** Software has been optimized to take advantage of CRAY-1 hardware.
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:** MAINSTREAM-EKS/VSP  
CRAYPACK Supplement to BCSLIB Users Manual.
- 14. Approximate cost of obtaining software:** CRAYPACK is available to BCS network users. Possibility of sale to interested organizations is under review.
- 15. Restrictions on use:** Use on BCS systems or if sold, internal use only. May not be distributed to others.
- 16. Distributor:** Boeing Computer Services Company
- 17. Original source of software:**
  - Developer:** D. S. Dodson
  - Institution:** Boeing Computer Services Company
  - Sponsor:** Boeing Computer Services Company
- 18. For further information contact:**
  - Kenneth W. Neves
  - Boeing Computer Services Company
  - 565 Andover Park West, MS 9C-01
  - Tukwila, WA 98188
  - (206) 575-5074

1. **Name of program or package:** MC19
2. **Descriptive title:** Scales a sparse matrix.
3. **Problem domain:** Sparse matrices.
4. **Method of solution:** Minimizes the sum of squares of the logarithms of the non-zeros.
5. **Programming language:** IBM Fortran.
6. **Precision:** Both single and double precision versions are available.
7. **Portability:** Fortran 66 version available.
8. **Other packages required:** None.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 174 **Percentage comments:** 24%
12. **Special features:**
13. **Documentation and references:**  
Detailed header comments? No.  
User guide or manual, technical reports, papers, books:  
Harwell Subroutine Library Specification Document.  
A.R.Curtis and J.K.Reid (1972) On the automatic scaling of matrices for Gaussian elimination. J. Inst. Math. Applics, **10**, 118-124.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (i), (ii), (iii), (iv) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell,  
Oxfordshire OX11 0RA, England.
17. **Original source of software:**  
Developer: J.K.Reid.  
Institution: A.E.R.E. Harwell.  
Sponsor: A.E.R.E. Harwell.
18. **For further information contact:** The developer.

- 1. Name of program or package:** HALFP
- 2. Descriptive title:** Computes the transpose of PA where P is a permutation matrix and A is sparse
- 3. Problem domain:** Used to reorder the rows and columns of a sparse matrix (form PAQ)
- 4. Method of solution:** Distribution count sort
- 5. Programming language:** FORTRAN
- 6. Precision:** Single and double precision
- 7. Portability:** IBM 370 in FORTRAN
- 8. Other packages required:** None
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 120 lines      **Percentage comments:** 50%
- 12. Special features:**
- 13. Documentation and references:**  
**Detailed header comments?** Yes  
**User guide or manual, technical reports, papers, books:**  
Two Fast Algorithms for Sparse Matrices: Multiplication and Permuted Transposition, ACM TOMS, Vol. 4, September 1978, pp. 250-269
- 14. Approximate cost of obtaining software:** See 18.
- 15. Restrictions on use:** None
- 16. Distributor:** Same as 18.
- 17. Original source of software:**  
**Developer:** Fred G. Gustavson  
**Institution:** IBM Research  
**Sponsor:**
- 18. For further information contact:**  
Dr. Fred G. Gustavson 33-205  
IBM T. J. Watson Research Center  
P.O. Box 218  
Yorktown Heights, New York 10598  
Phone: (914) 945-1980

1. **Name of program or package:** TRANS
2. **Descriptive title:** to permute the rows (if matrix stored row wise) and transpose a sparse matrix, so large that only one fits in core.
3. **Problem domain:** sparse matrix data management
4. **Method of solution:** distribution of non zeros among row queues
5. **Programming language:** ANSI Standard Fortran
6. **Precision:** either
7. **Portability:** developed on a Cyber, but very portable
8. **Other packages required:** none
9. **Mode of use:** callable subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 150                      **Percentage comments:** 25%
12. **Special features:** writes output directly into secondary storage.
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:** none at present time
14. **Approximate cost of obtaining software:** free
15. **Restrictions on use:** none
16. **Distributor:** same as 18
17. **Original source of software:**
  - Developer:** Oleg Vishnepolsky
  - Institution:** Institute for Economic Analysis, New York University
  - Sponsor:**
18. **For further information contact:** Daniel B. Szyld  
Institute for Economic Analysis  
New York University  
269 Mercer Street  
New York, NY 10003  
Phone (212) 598 3413



- 1. Name of program or package:** MC22
- 2. Descriptive title:** Permutes a sparse matrix.
- 3. Problem domain:** Sparse matrices.
- 4. Method of solution:**
- 5. Programming language:** IBM Fortran.
- 6. Precision:** Both single and double precision versions are available.
- 7. Portability:** Fortran 66 version available.
- 8. Other packages required:** None.
- 9. Mode of use:** Subroutine calls.
- 10. Test of demonstration program available:** Yes.
- 11. Length of code in lines:** 78 **Percentage comments:** 35%
- 12. Special features:** Complex version (ME22) available.
- 13. Documentation and references:**
  - Detailed header comments?** No.
  - User guide or manual, technical reports, papers, books:**
    - Harwell Subroutine Library Specification Document.
- 14. Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
- 15. Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
- 16. Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell, Oxfordshire OX11 0RA, England.
- 17. Original source of software:**
  - Developer:** I.S.Duff.
  - Institution:** A.E.R.E. Harwell.
  - Sponsor:** A.E.R.E. Harwell.
- 18. For further information contact:** The developer.

1. **Name of program or package:** MC20
2. **Descriptive title:** Sorts non-zeros.
3. **Problem domain:** Sparse matrices.
4. **Method of solution:** In place sort by columns, handling each non-zero just once.
5. **Programming language:** IBM Fortran.
6. **Precision:** Both single and double precision versions are available.
7. **Portability:** Fortran 66 version available.
8. **Other packages required:** None.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 103 **Percentage comments:** 33%
12. **Special features:** *Optional second entry bubble-sorts each column.*
13. **Documentation and references:**
  - Detailed header comments?** No.
  - User guide or manual, technical reports, papers, books:**
    - Harwell Subroutine Library Specification Document.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell, Oxfordshire OX11 0RA, England.
17. **Original source of software:**
  - Developer:** A.W.Westerberg and J.K.Reid.
  - Institution:** A.E.R.E. Harwell.
  - Sponsor:** A.E.R.E. Harwell.
18. **For further information contact:** J.K.Reid.

1. **Name of program or package:** SUBMAT
2. **Descriptive title:** Submatrices and/or row and column permutations of a sparse matrix
3. **Problem domain:** Sparse Matrix data management
4. **Method of solution:** See 12
5. **Programming language:** ANSI standard FORTRAN
6. **Precision:** Either
7. **Portability:** Developed on IBM, used on a Cyber, Portable IBM version with half word integers also available
8. **Other packages required:** None
9. **Mode of use:** Callable subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 75                      **Percentage comments:** 40%
12. **Special features:** If one considers the indicators for a subset of rows (or columns) as an application, say  $A: R^n \rightarrow R^m$ , the code uses the inverse application  $B: \text{Rank}(A) \rightarrow R^n$
13. **Documentation and references:**  
**Detailed header comments?** Yes  
**User guide or manual, technical reports, papers, books:**  
 Proceedings, of the "I Jornadas Latinoamericanas de Matematica Aplicada" held in Santiago, Chile, December 1981
14. **Approximate cost of obtaining software:** Free
15. **Restrictions on use:** None
16. **Distributor:** Same as 18
17. **Original source of software:**  
**Developer:** Daniel B. Szyld  
**Institution:** Institute for Economic Analysis, New York University  
**Sponsor:**
18. **For further information contact:**  
 Daniel B. Szyld  
 Institute for Economic Analysis  
 New York University  
 269 Mercer Street  
 New York, N.Y. 10003  
 Phone: (212) 598-3413

- 1. Name of program or package:** FULL ASSIGN
- 2. Descriptive title:** Compute a maximal assignment for an arbitrary 0-1 matrix
- 3. Problem domain:** Arbitrary Sparse (0-1) Matrix
- 4. Method of solution:** The Assign Row Algorithm of Gustavson - a modification of M. Hall's algorithm for finding an assignment
- 5. Programming language:** APL, FORTRAN and 370 BAL versions
- 6. Precision:** Single precision (only fixed point computations)
- 7. Portability:** Standard ANSI FORTRAN
- 8. Other packages required:** None
- 9. Mode of use:** Callable FORTRAN subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** about 150      **Percentage comments:** about 60%
- 12. Special features:** Fast and 100% accurate
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**

Finding the Block Lower Triangular Form of a Sparse Matrix - Sparse Matrix Computations, J. R. Bunch and D. J. Rose (eds.) Academic Press, 1976, pp. 275-289
- 14. Approximate cost of obtaining software:** See 18.
- 15. Restrictions on use:** None
- 16. Distributor:** Same as 18.
- 17. Original source of software:**
  - Developer:** Fred G. Gustavson
  - Institution:** IBM Research
  - Sponsor:**
- 18. For further information contact:**

Dr. Fred G. Gustavson 33-205  
IBM T. J. Watson Research Center  
P.O. Box 218  
Yorktown Heights, New York 10598  
Phone: (914) 945-1980

- 1. Name of program or package:** MC21
- 2. Descriptive title:** Find a permutation to place non-zeros on the diagonal.
- 3. Problem domain:** Sparse matrices.
- 4. Method of solution:** Depth-first search with look-ahead.
- 5. Programming language:** IBM Fortran.
- 6. Precision:** Not applicable, since it works on the sparsity pattern.
- 7. Portability:** Fortran 66 version available.
- 8. Other packages required:** None.
- 9. Mode of use:** Subroutine calls.
- 10. Test of demonstration program available:** Yes.
- 11. Length of code in lines:** 118 **Percentage comments:** 31%
- 12. Special features:**
- 13. Documentation and references:**  
**Detailed header comments?** No.  
**User guide or manual, technical reports, papers, books:**  
 Harwell Subroutine Library Specification Document.  
 I.S.Duff (1981) On algorithms for obtaining a maximum transversal. A.C.M. Trans. Math. Software, 7, 315-330 and 387-390.
- 14. Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
- 15. Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
- 16. Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell, Oxfordshire OX11 0RA, England.
- 17. Original source of software:**  
**Developer:** I.S.Duff.  
**Institution:** A.E.R.E. Harwell.  
**Sponsor:** A.E.R.E. Harwell.
- 18. For further information contact:** The developer.

- 1. Name of program or package:** BLTF
- 2. Descriptive title:** Compute the block lower triangular form of a Sparse Matrix
- 3. Problem domain:**
- 4. Method of solution:** A new improved version of Tarjan's Strong Connect Algorithm
- 5. Programming language:** APL, FORTRAN and 370 BAL
- 6. Precision:** Single precision
- 7. Portability:** Standard FORTRAN
- 8. Other packages required:** None
- 9. Mode of use:** Callable FORTRAN subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** About 150      **Percentage comments:** About 60%
- 12. Special features:** Fast and 100% accurate
- 13. Documentation and references:**  
**Detailed header comments?** Yes  
**User guide or manual, technical reports, papers, books:**  
Finding the Block Lower Triangular Form of a Sparse Matrix - Sparse Matrix Computations, J. R. Bunch and D. J. Rose (eds.) Academic Press, 1976, pp. 275-289
- 14. Approximate cost of obtaining software:** See 18.
- 15. Restrictions on use:** None
- 16. Distributor:** Same as 18.
- 17. Original source of software:**  
**Developer:** Fred G. Gustavson  
**Institution:** IEM Research  
**Sponsor:**
- 18. For further information contact:**  
Dr. Fred G. Gustavson 33-205  
IBM T. J. Watson Research Center  
P.O. Box 218  
Yorktown Heights, New York 10598  
Phone: (914) 945-1980

- 1. Name of program or package:** MC13
- 2. Descriptive title:** Finds a symmetric permutation for block triangular form.
- 3. Problem domain:** Sparse matrices.
- 4. Method of solution:** Tarjan's algorithm.
- 5. Programming language:** IBM Fortran.
- 6. Precision:** Not applicable, since it works on the sparsity pattern.
- 7. Portability:** Fortran 66 version available.
- 8. Other packages required:** None.
- 9. Mode of use:** Subroutine calls.
- 10. Test of demonstration program available:** Yes.
- 11. Length of code in lines:** 131 **Percentage comments:** 46%
- 12. Special features:**
- 13. Documentation and references:**  
**Detailed header comments?** No.  
**User guide or manual, technical reports, papers, books:**  
 Harwell Subroutine Library Specification Document.  
 R.Tarjan (1972) Depth first search and linear graph algorithms. S.I.A.M. J. Comput. **1**, 146-160.  
 I.S.Duff and J.K.Reid (1978) An implementation of Tarjan's algorithm for the block triangularization of a matrix. A.C.M. Trans. Math. Software **4**, 137-147 and 189-192.
- 14. Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
- 15. Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
- 16. Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell, Oxfordshire OX11 0RA, England, or I.M.S.L. (TOMS algorithm).
- 17. Original source of software:**  
**Developer:** I.S.Duff  
**Institution:** A.E.R.E. Harwell.  
**Sponsor:** A.E.R.E. Harwell.
- 18. For further information contact:** The developer.

1. **Name of program or package:** MC23
2. **Descriptive title:** Permutes a sparse matrix to block triangular form.
3. **Problem domain:** Sparse matrices.
4. **Method of solution:** Uses Harwell routines MC13 and MC21.
5. **Programming language:** IBM Fortran
6. **Precision:** Both single and double precision versions are available.
7. **Portability:** Fortran 66 version available.
8. **Other packages required:** Harwell subroutines MC13, MC21.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 202 **Percentage comments:** 41%  
(451 with dependencies)
12. **Special features:** Complex version (ME23) available.
13. **Documentation and references:**  
Detailed header comments? No.  
User guide or manual, technical reports, papers, books:  
Harwell Subroutine Library Specification Document.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell,  
Oxfordshire OX11 0RA, England.
17. **Original source of software:**  
Developer: I.S.Duff.  
Institution: A.E.R.E. Harwell.  
Sponsor: A.E.R.E. Harwell.
18. **For further information contact:** The developer.



1. **Name of program or package:** GPSKCA, GPSKRA
2. **Descriptive title:** Bandwidth and profile (envelope) reduction.
3. **Problem domain:** Reordering algorithm for symmetric matrices.
4. **Method of solution:** Uses Gibbs-Poole, Stockmeyer and Gibbs-King algorithms.
5. **Programming language:** FORTRAN
6. **Precision:** Integer (nonzero values are not required; only locations).
7. **Portability:** Developed on CDC CYBER 760; portable.
8. **Other packages required:** None
9. **Mode of use:** Subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 2500 lines      **Percentage comments:** 50%
12. **Special features:** GPSKCA uses compact (linked lists) data format; GPSKRA uses rectangular array for connection table. Improved version of Algorithms 508, 509 (TOMS, December 1976). These new codes appeared in TOMS (June 1982).
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:** Description appeared in TOMS (June 1982).
14. **Approximate cost of obtaining software:** Standard TOMS fee.
15. **Restrictions on use:** None
16. **Distributor:** ACM TOMS
17. **Original source of software:**
  - Developer:** J.G. Lewis modified 508, 509 (developed by Crane, Gibbs, Poole, Stockmeyer).
  - Institution:** Boeing Computer Services Company
  - Sponsor:** Boeing Computer Services Company
18. **For further information contact:**
  - J.G. Lewis
  - Boeing Computer Services Company
  - 565 Andover Park West, MS 9C-01
  - Tukwila, WA 98188
  - (206) 575-5102

**1. Name of program or package:****2. Descriptive title:**

**3. Problem domain:** Packing of the integer (index) vectors and matrices  
of the NAG Sparse routines

**4. Method of solution:**

**5. Programming language:** FORTRAN 66

**6. Precision:**

**7. Portability:** Only the packing routines are machine dependent, the packing  
is done by subroutine calls or function calls

**8. Other packages required:** NAG Library

**9. Mode of use:** Subroutine calls

**10. Test or demonstration program available?**

**11. Length of code in lines:** **Percentage comments:**

**12. Special features:****13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:**

User guide but only in German at the moment

Sparse Matrices and their Uses, I. S. Duff (ed.) Academic Press, London  
(1981) pp. 335-341

**14. Approximate cost of obtaining software:**

**15. Restrictions on use:** Contracts with NAG

**16. Distributor:****17. Original source of software:**

**Developer:** U. Harms

**Institution:** RRZN

**Sponsor:**

**18. For further information contact:**

U. Harms  
RRZN  
Wunstorfer Strasse 14  
D-3000 Hannover 91  
West Germany

- 1. Name of program or package:** VMSYST
- 2. Descriptive title:** Numerical data management system
- 3. Problem domain:** General purpose support - large volumes of data
- 4. Method of solution:** Page buffering; "Least recently used" paging algorithm
- 5. Programming language:** FORTRAN 66
- 6. Precision:** NA
- 7. Portability:** Good (Currently operational on: VAX 11/780, UNIVAC 11XX)
- 8. Other packages required:** DMGASP (or suitable I/O interface)
- 9. Mode of use:** Subroutine calls
- 10. Test or demonstration program available?** Included
- 11. Length of code in lines:** 1800                      **Percentage comments:** 0
- 12. Special features:** Manages mass storage as a "virtual" word addressable memory or as a record file; Maintains file descriptive header; has a "note" (text) stack system.
- 13. Documentation and references:**
  - Detailed header comments?** Practically none in code
  - User guide or manual, technical reports, papers, books:**
    - "Supplementary Studies on the Sensitivity of Optimized Structures," AFWAL-TR-81-3013, National Technical Information Service (NTIS), 425 13th St., N.W., Washington, D.C. (March 1981).
- 14. Approximate cost of obtaining software:** \$300
- 15. Restrictions on use:** Not to be re-distributed
- 16. Distributor:** Lockheed Research Lab.
- 17. Original source of software:**
  - Developer:** Paul S. Jensen
  - Institution:** Lockheed Palo Alto Research Laboratory
  - Sponsor:** AFOSR, ONERA, Lockheed Ind. Research
- 18. For further information contact:**
  - Paul S. Jensen
  - Lockheed Research Lab. 5233/255
  - 3251 Hanover St.
  - Palo Alto, CA 94304

- 1. Name of program or package:** FFTPACK
- 2. Descriptive title:** Subprograms for the fast Fourier transform of real, complex and symmetric sequences
- 3. Problem domain:** Real, complex and symmetric sequences
- 4. Method of solution:** Stockham auto-sort algorithm
- 5. Programming language:** ANSI FORTRAN
- 6. Precision:** Single
- 7. Portability:** Developed on the Cray-1 but is easily ported
- 8. Other packages required:** None
- 9. Mode of use:** Subprogram
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 2,000      **Percentage comments:** 30%
- 12. Special features:** Nineteen subprograms for the fast transform of real, complex, real-even, real-odd and quarter wave transforms
- 13. Documentation and references:** Yes, included with package  
**Detailed header comments?** Yes  
**User guide or manual, technical reports, papers, books:**  
Paul N. Swartztrauber, Vectorizing the FFT's, in Parallel Computations,  
Garry Rodrigue (ed.) Academic Press, 1982
- 14. Approximate cost of obtaining software:** \$300
- 15. Restrictions on use:** None
- 16. Distributor:** Scientific Computing Division  
National Center for Atmospheric Research  
P.O. Box 3000, Boulder, Colorado 80307
- 17. Original source of software:** Same as 16.  
**Developer:** Paul N. Swartztrauber  
**Institution:** NCAR  
**Sponsor:** NSF
- 18. For further information contact:**  
To order, contact Sue Long, NCAR (303) 494-5151, Ext. 505 or FTS 322-5505  
Questions to Paul N. Swartztrauber (303) 494-5151, Ext. 605 or  
FTS 322-5605.

1. **Name of program or package:** F01BRF/A
2. **Descriptive title:** Decomposes a real sparse matrix
3. **Problem domain:** Real, linear equations.
4. **Method of solution:** LU decomposition
5. **Programming language:** FORTRAN and Algol 60
6. **Precision:** Either
7. **Portability:** Available on 48 machine ranges/compliers
8. **Other packages required:** NAG
9. **Mode of use:** Callable subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 294                      **Percentage comments:** 50%
12. **Special features:**
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - NAG Library Manual
    - NAG On-line Supplement
14. **Approximate cost of obtaining software:** NAG Library costs \$1584/year
15. **Restrictions on use:** License agreement
16. **Distributor:** NAG (U.S.A.) Inc.  
(see below)
17. **Original source of software:**
  - Developer:** Dr. I. Duff
  - Institution:** Harwell (U.K.)
  - Sponsor:** NAG
18. **For further information contact:**
  - Mrs. Carolyn M. Smith
  - NAG (U.S.A.) Inc.
  - 1250 Grace Court
  - Downers Grove, IL 60516
  - Tel. 971-2337
  - Telex 23254708 (Teleserv DFLD)

- 1. Name of program or package:** F01BSF/A
- 2. Descriptive title:** Decomposes a real sparse matrix using pivotal sequence previously determined
- 3. Problem domain:** Real, linear, algebraic equations
- 4. Method of solution:** LU decomposition
- 5. Programming language:** FORTRAN and Algol 60
- 6. Precision:** Either
- 7. Portability:** Available on 48 machine ranges/compiler
- 8. Other packages required:** NAG
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 132      **Percentage comments:** 50%
- 12. Special features:**
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - NAG Library Manual
    - NAG On-line Supplement
- 14. Approximate cost of obtaining software:** NAG Library costs \$1584/year
- 15. Restrictions on use:** License agreement
- 16. Distributor:** NAG (U.S.A.) Inc.  
(see below)
- 17. Original source of software:**
  - Developer:** Dr. I. Duff
  - Institution:** Harwell (U.K.)
  - Sponsor:** NAG
- 18. For further information contact:**
  - Mrs. Carolyn M. Smith
  - NAG (U.S.A.) Inc.
  - 1250 Grace Court
  - Downers Grove, IL 60516
  - Tel. 971-2337
  - Telex 23254708 (Teleserv DFLD)

1. **Name of program or package:** F04AXF/A
2. **Descriptive title:** Solves a system of linear equations
3. **Problem domain:** Real, sparse, linear algebraic equations
4. **Method of solution:** LU decomposition
5. **Programming language:** FORTRAN and Algol 60
6. **Precision:** Either
7. **Portability:** Available on 48 machine ranges/compliers
8. **Other packages required:** NAG
9. **Mode of use:** Callable subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 42      **Percentage comments:** 75%
12. **Special features:**
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - NAG Library Manual
    - NAG On-line Supplement
14. **Approximate cost of obtaining software:** NAG Library costs \$1584/year
15. **Restrictions on use:** License agreement
16. **Distributor:** NAG (U.S.A.) Inc.  
(see below)
17. **Original source of software:**
  - Developer:** Dr. I. Duff
  - Institution:** Harwell
  - Sponsor:** NAG
18. **For further information contact:**
  - Mrs. Carolyn M. Smith
  - NAG (U.S.A.) Inc.
  - 1250 Grace Court
  - Downers Grove, IL 60516
  - Tel. 971-2337
  - Telex. 23254708 (Teleserv DFLD)

1. **Name of program or package:** MA28/MA30
2. **Descriptive title:** Solves linear sets of equations.
3. **Problem domain:** Sparse unsymmetric matrices.
4. **Method of solution:** LU decomposition, using Markowitz' pivoting.
5. **Programming language:** IBM Fortran.
6. **Precision:** Both single and double precision versions are available.
7. **Portability:** Fortran 66 version available.
8. **Other packages required:** Harwell subroutines MC13, MC20, MC21, MC22, MC23, MC24.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 1842 **Percentage comments:** 37%  
(2520 with dependencies)
12. **Special features:** Includes automatic recognition of block triangular form. Complex version (ME28/ME30) available. Direct entry available (MA30/ME30) for sorted matrices.
13. **Documentation and references:**  
**Detailed header comments?** Yes.  
**User guide or manual, technical reports, papers, books:**  
Harwell Subroutine Library Specification Document.  
I.S.Duff and J.K.Reid (1979), A.C.M. Trans. on Math. Software, **5**, 18-35.  
I.S.Duff (1977), MA28 - A set of Fortran subroutines for sparse unsymmetric linear equations. Harwell report R-8730, H.M.S.O., London.  
I.S.Duff (1981) A.C.M. Trans. Math. Software, **7**, 505-511.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (i), (ii), (iii), (iv) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 9.9, A.E.R.E. Harwell,  
Oxfordshire OX11 0RA, England.
17. **Original source of software:**  
**Developer:** I.S.Duff  
**Institution:** A.E.R.E. Harwell.  
**Sponsor:** A.E.R.E. Harwell.
18. **For further information contact:** The developer.



1. **Name of program or package:** MA32
2. **Descriptive title:** Solves unsymmetric sets of linear equations.
3. **Problem domain:** Finite element or finite difference equations.
4. **Method of solution:** Frontal elimination.
5. **Programming language:** IBM and CRAY Fortran.
6. **Precision:** Double precision (IBM) and single precision (CRAY).
7. **Portability:** Written in Fortran 66 except for isolated direct-access i/o statements.
8. **Other packages required:** IBM version calls other Harwell routines to establish files.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 2211 **Percentage comments:** 45%  
(2522 with dependencies)
12. **Special features:** Allows problems to be input by rows or by finite elements. Uses direct access storage.
13. **Documentation and references:**
  - Detailed header comments?** Yes, of auxiliary routines.
  - User guide or manual, technical reports, papers, books:**
    - Harwell Subroutine Library Specification Document.
    - I.S.Duff (1981) Design features of a code for solving sparse unsymmetric linear systems out-of-core. Harwell report CSS 89.
    - I.S.Duff (1981) MA32 – A package for solving sparse unsymmetric systems using the frontal method. Harwell report R-10079.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (i), (ii), (iii), (iv) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell, Oxfordshire OX11 0RA, England.
17. **Original source of software:**
  - Developer:** I.S.Duff.
  - Institution:** A.E.R.E. Harwell.
  - Sponsor:** A.E.R.E. Harwell.
18. **For further information contact:** The developer.

1. **Name of program or package:** MC24
2. **Descriptive title:** Bounds the size of non-zeros encountered in Gaussian elimination.
3. **Problem domain:** Sparse LU decomposition.
4. **Method of solution:** Hadamard's inequality.
5. **Programming language:** IBM Fortran.
6. **Precision:** Both single and double precision versions are available.
7. **Portability:** Fortran 66 version available.
8. **Other packages required:** None
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 46 **Percentage comments:** 32%
12. **Special features:** Complex version (ME24) available.
13. **Documentation and references:**
  - Detailed header comments?** No.
  - User guide or manual, technical reports, papers, books:**
    - Harwell Subroutine Library Specification Document.
    - A.M.Erisman and J.K.Reid (1974) Monitoring the stability of the triangular factorization of a sparse matrix. Numer. Math. **22**, 183-186.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell, Oxfordshire OX11 0RA, England.
17. **Original source of software:**
  - Developer:** I.S.Duff.
  - Institution:** A.E.R.E. Harwell.
  - Sponsor:** A.E.R.E. Harwell.
18. **For further information contact:** The developer.

1. **Name of program or package:** NSPFAC
2. **Descriptive title:** Sparse Linear Equation Solver
3. **Problem domain:** Nonsymmetric Sparse Linear Equations
4. **Method of solution:** Sparse Gaussian Elimination with threshold partial pivoting
5. **Programming language:** Fortran
6. **Precision:** Single or Double available (Separately)
7. **Portability:** Developed on DEC-10, IBM/360, CDC-6600  
Easily portable to other machines
8. **Other packages required:** None
9. **Mode of use:** Callable subroutines
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 400                      **Percentage comments:** 61%
12. **Special features:** None
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - A. H. Sherman, Algorithm 533-NSPIV, A Fortran Subroutine for Sparse Gaussian Elimination with Partial Pivoting, Trans. on Math Software 4 (Dec., 1978), pp. 391-398.
    - A. H. Sherman, Algorithms for Sparse Gaussian Elimination with Partial Pivoting, Trans. on Math Software 4 (Dec. 1978), pp. 330-338.
14. **Approximate cost of obtaining software:** No Cost
15. **Restrictions on use:** None
16. **Distributor:** Andrew H. Sherman  
Exxon Production Research Co.  
P. O. Box 2189  
Houston, TX 77001                      713/966-6376
17. **Original source of software:**
  - Developer:** Andrew H. Sherman
  - Institution:** University of Texas at Austin
  - Sponsor:** AFOSR
18. **For further information contact:**
  - Andrew H. Sherman
  - Exxon Production Research Co.
  - P. O. Box 2189
  - Houston, TX 77001
  - 713/966-6376

- 1. Name of program or package:** PORT Sparse Matrix Package
- 2. Descriptive title:** Subroutines for solving sparse unsymmetric linear systems have been added to the PORT library.
- 3. Problem domain:** Systems of linear equations, real and complex, nonsymmetric, sparse
- 4. Method of solution:** Direct methods, some subroutines do minimum degree ordering, others do threshold pivoting for stability given an initial ordering.
- 5. Programming language:** FORTRAN
- 6. Precision:** Single and double
- 7. Portability:** As portable as PORT, checked by PFORT verifier
- 8. Other packages required:** Core subroutines in PORT which are in public domain
- 9. Mode of use:** Callable subroutines
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 8800 lines      **Percentage comments:** 20%
- 12. Special features:** Has easy to use subroutines and subroutines for problems with a number of matrices all with the same zero structure. Permits function input of matrices.
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - User guide available
- 14. Approximate cost of obtaining software:** \$75 to universities, one time charge
- 15. Restrictions on use:** License agreement
- 16. Distributor:** Until third version of PORT library is released for distribution contact - Linda Kaufman, Bell Labs, Room 2C-459, Murray Hill, N.J. 07974
- 17. Original source of software:**
  - Developer:** Linda Kaufman
  - Institution:** Bell Labs
  - Sponsor:**
- 18. For further information contact:**
  - Linda Kaufman
  - Bell Labs
  - Room 2C-459
  - Murray Hill, N.J. 07974

1. **Name of program or package:** SSLEST
2. **Descriptive title:** LU-decomposition of general sparse matrix
3. **Problem domain:** Solution of systems of linear equations
4. **Method of solution:** Gaussian elimination with pivoting using Markowitz-strategy involving stability checking and dropping tolerance
5. **Programming language:** FORTRAN
6. **Precision:** Single precision IBM
7. **Portability:** Uses INTEGER\*2 to save space
8. **Other packages required:** NONE
9. **Mode of use:** Callable subroutines
10. **Test or demonstration program available?** NO
11. **Length of code in lines:** 750 lines      **Percentage comments:** 10% comments
12. **Special features:** The features of using drop-tolerance, selecting different pivoting strategies and of modifying the stability check are available. 8 different modes of operation
13. **Documentation and references:**
  - Detailed header comments?**
  - User guide or manual, technical reports, papers, books:**
    - Users Guide available, require rep. NI-78-01, gives detailed information on use and examples
14. **Approximate cost of obtaining software:** 50 \$
15. **Restrictions on use:** Non-commercial
16. **Distributor:** Dept. for Numerical Analysis  
Technical University of Denmark, Building 303  
DK-2800 Lyngby, Denmark
17. **Original source of software:**
  - Developer:** Z. Zlatev, V.A. Barker, P.G. Thomsen
  - Institution:** Dept. of Numerical Analysis, Technical University of Denmark
  - Sponsor:**
18. **For further information contact:** Per Grove Thomsen  
Dept. for Numerical Analysis, Building 303  
Technical University of Denmark, DK-2800 Lyngby  
DENMARK, Tel. 881911 ext. 4373

- 1. Name of program or package:** Y12M
- 2. Descriptive title:** Sparse linear systems package
- 3. Problem domain:** Unsymmetric linear systems
- 4. Method of solution:** Gaussian elimination with a generalized Markowitz strategy; iterative refinement as an option
- 5. Programming language:** ANSI FORTRAN
- 6. Precision:** Both single and double precision versions for the direct solution option; mixed arithmetic in the IR option
- 7. Portability:** Portable
- 8. Other packages required:** None
- 9. Mode of use:** Callable subroutines
- 10. Test or demonstration program available?** Yes, several test-matrices generators
- 11. Length of code in lines:** about 2000      **Percentage comments:** 10%
- 12. Special features:** Multibanking option for the UNIVAC 1100 installations
- 13. Documentation and references:**
  - Detailed header comments?** No
  - User guide or manual, technical reports, papers, books:**
    - "Y12M - Solution of Large and Sparse Systems of Linear Algebraic Equations", Lecture Notes in Computer Science, Vol. 121, Springer, SIAM J. Numer. Anal. 17(1980), 19(1982); Comp. Chem. 4(1980), 5(1981)
- 14. Approximate cost of obtaining software:** Free of charge
- 15. Restrictions on use:** None
- 16. Distributor:** Recku (Regional Computing Centre at the University of Copenhagen)
- 17. Original source of software:**
  - Developer:** Z.Zlatev, J.Wasniewski and K.Schaumburg
  - Institution:** Recku, Copenhagen
  - Sponsor:** Danish Natural Science Research Council
- 18. For further information contact:** J.Wasniewski, Regional Computing Centre
  - at the University of Copenhagen,
  - Vermundsgade 5, 2100 Copenhagen Ø
  - Tlf. 01 - 83 95 11

- 1. Name of program or package:** General Sparse Solver (SYMFAC, NUMFAC  
AND BKSOLVE)
- 2. Descriptive title:** General sparse linear system solver
- 3. Problem domain:** Unsymmetric linear equation solver
- 4. Method of solution:** SYMFAC - NUMFAC approach
- 5. Programming language:** FORTRAN
- 6. Precision:** Single and double precision
- 7. Portability:** Standard FORTRAN
- 8. Other packages required:**
- 9. Mode of use:** Callable FORTRAN subroutines
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** about 500      **Percentage comments:** about 50%
- 12. Special features:**

**13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:**

Some Results on Sparse Matrices, IBM Research Report 1980

"Some Basic Techniques for Solving Sparse Systems of Linear Equations,"

Sparse Matrices and their Applications, D. J. Rose and R. A. Willoughby  
(eds.) Plenum Press, 1972, pp. 41-52

**14. Approximate cost of obtaining software:** See 18.

**15. Restrictions on use:** None

**16. Distributor:** Same as 18.

**17. Original source of software:**

**Developer:** Fred G. Gustavson

**Institution:** IBM Research

**Sponsor:**

**18. For further information contact:**

Dr. Fred G. Gustavson 33-205  
IBM T. J. Watson Research Center  
P.O. Box 218  
Yorktown Heights, New York 10598  
Phone: (914) 945-1980

1. **Name of program or package:** GNSO
2. **Descriptive title:** Symbolic Generation of an Optimal Crout Algorithm
3. **Problem domain:** Unsymmetric linear equation solver
4. **Method of solution:** Compiled code approach
5. **Programming language:** FORTRAN
6. **Precision:** Single and double precision
7. **Portability:** Standard FORTRAN
8. **Other packages required:** None
9. **Mode of use:** Callable FORTRAN subroutines
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 1000 lines      **Percentage comments:** 30%
12. **Special features:**
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - "Symbolic Generation of an Optimal Crout Algorithm," J. ACM, January 1970
14. **Approximate cost of obtaining software:** See 18.
15. **Restrictions on use:** None
16. **Distributor:** Same as 18.
17. **Original source of software:**
  - Developer:** Fred G. Gustavson
  - Institution:** IBM Research
  - Sponsor:**
18. **For further information contact:**
  - Dr. Fred G. Gustavson 33-205
  - IBM T. J. Watson Research Center
  - P.O. Box 218
  - Yorktown Heights, New York 10598
  - Phone: (914) 945-1980



1. **Name of program or package:** SPAR/VECTOR
2. **Descriptive title:** General Sparse Solver for CRAY-1
3. **Problem domain:** Unsymmetric sparse matrices
4. **Method of solution:** LU factorization
5. **Programming language:** Fortran
6. **Precision:** 64-Bit
7. **Portability:** CRAY-1, CRAY-1S, CRAY X-MP, CYBER 205
8. **Other packages required:** None
9. **Mode of use:** Subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 700                      **Percentage comments:** 20
12. **Special features:** Two-pass symbolic/numeric. From column-ordered symbolic matrix description and row and column permutation vectors, dense segments of columns are tagged for later processing in vector mode.
13. **Documentation and references:**  
    **Detailed header comments?**  
    **User guide or manual, technical reports, papers, books:**  
    "A Collection of Sparse Matrix Solvers for the CRAY-1", Report #166, Systems Engineering Laboratory, University of Michigan, Ann Arbor, MI 48109; October, 1982.
14. **Approximate cost of obtaining software:** Send user tape
15. **Restrictions on use:** None
16. **Distributor:** See Below
17. **Original source of software:**  
    **Developer:** D.A. Calahan, Dept. of Elec. & Comp. Engineering  
    **Institution:** University of Michigan, Ann Arbor, MI 48109; 313-763-0036  
    **Sponsor:** Air Force Office of Scientific Research
18. **For further information contact:** See Above

1. **Name of program or package:** SPAR/SC/CRAY
2. **Descriptive title:** General Sparse Solver for CRAY-1 by Loopless Scalar Code Generation
3. **Problem domain:** Unsymmetric highly sparse matrices
4. **Method of solution:** LU factorization
5. **Programming language:** Fortran and CRAY Assembly Language
6. **Precision:** 64-Bit
7. **Portability:** CRAY-1, CRAY-1S, CRAY X-MP
8. **Other packages required:** None
9. **Mode of use:** Stand-alone; easily modified to subroutine
10. **Test or demonstration program available?**
11. **Length of code in lines:** 1600                      **Percentage comments:** 20
12. **Special features:** Two-pass symbolic/numeric. After special equation ordering to maximize local decoupling, loopless scalar code is generated in symbolic phase. Achieves 14-16 MFLOPS.
13. **Documentation and references:**
  - Detailed header comments?** No
  - User guide or manual, technical reports, papers, books:**
    - "A Collection of Sparse Matrix Solvers for the CRAY-1", Report #166, Systems Engineering Laboratory, University of Michigan, Ann Arbor, MI 48109; October, 1982.
14. **Approximate cost of obtaining software:** Send user tape
15. **Restrictions on use:** None
16. **Distributor:** See Below
17. **Original source of software:**
  - Developer:** D.A. Calahan, Dept. of Elec. & Comp Engineering
  - Institution:** University of Michigan, Ann Arbor, MI 48109
  - Sponsor:** Air Force Office of Scientific Research
18. **For further information contact:** See Above

- 1. Name of program or package:** RUF5
- 2. Descriptive title:** Sparse linear system solver
- 3. Problem domain:** Real, unsymmetric linear systems
- 4. Method of solution:** LU Decomposition
- 5. Programming language:** Assembly Language - FPS-164 Array Processor
- 6. Precision:** 64-bit word
- 7. Portability:** Developed for the FPS-164 Array Processor. A version also exists for the following FPS 38-bit Array Processors: FPS-100, AP-120B, AP-180V, and AP-190L.
- 8. Other packages required:** FPS-164 Math Library (APMATH64)
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** No
- 11. Length of code in lines:** 1017                      **Percentage comments:** 70
- 12. Special features:** Takes advantage of the parallel, pipelined architecture of the FPS-164 Array Processor.
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - APMATH64 Reference Manual
    - Floating Point Systems, Inc.
- 14. Approximate cost of obtaining software:** This routine is included in the FPS-164 Math Library (APMATH64).
- 15. Restrictions on use:** License agreement required
- 16. Distributor:** Floating Point Systems, Inc.
  - P.O. Box 23489
  - Portland, OR 97223
  - (503) 641-3151
- 17. Original source of software:**
  - Developer:** Ron Coleman
  - Institution:** Floating Point Systems, Inc.
  - Sponsor:** Floating Point Systems, Inc.
- 18. For further information contact:**
  - Phil Vaughn
  - Floating Point Systems, Inc.
  - P.O. Box 23489
  - Portland, OR 97223
  - (503) 641-3151                      TLX: 360470 FLOATPOIN BEAV

1. **Name of program or package:** CUFS
2. **Descriptive title:** Sparse linear system solver
3. **Problem domain:** Complex, unsymmetric linear systems
4. **Method of solution:** LU Decomposition
5. **Programming language:** FPS-164 Array Processor
6. **Precision:** 64-bit word
7. **Portability:** Developed for the FPS-164 Array Processor. A version also exists for the following FPS 38-bit Array Processors:  
FPS-100, AP-120B, AP-180V, and AP-190L.
8. **Other packages required:** FPS-164 Math Library (APMATH64)
9. **Mode of use:** Callable subroutine
10. **Test or demonstration program available?** No
11. **Length of code in lines:** 1212 **Percentage comments:** 70
12. **Special features:** Takes advantage of the parallel, pipelined architecture of the FPS-164 Array Processor.
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**  
APMATH64 Reference Manual  
Floating Point Systems, Inc.
14. **Approximate cost of obtaining software:** This routine is included in the FPS-164 Math Library (APMATH64).
15. **Restrictions on use:** License agreement required
16. **Distributor:** Floating Point Systems, Inc.  
P.O. Box 23489  
Portland, OR 97223  
(503) 641-3151
17. **Original source of software:**
  - Developer:** Ron Coleman
  - Institution:** Floating Point Systems, Inc.
  - Sponsor:** Floating Point Systems, Inc.
18. **For further information contact:**
  - Phil Vaughn
  - Floating Point Systems, Inc.
  - P.O. Box 23489
  - Portland, OR 97223
  - (503) 641-3151 TLX: 360470 FLOATPOIN BEAV

1. **Name of program or package:** ECTLIB
2. **Descriptive title:** Subroutines for out-of-core solutions of large complex linear systems
3. **Problem domain:** The solving of large linear complex systems
4. **Method of solution:** Sherman-Morrison Updating formula
5. **Programming language:** FORTRAN IV
6. **Precision:** Single
7. **Portability:** CDC CYBER 170 Series
8. **Other packages required:** No
9. **Mode of use:** Stand Alone
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 3530      **Percentage comments:**
12. **Special features:**

Applicable to both dense and sparse matrices that are too large to be stored in core
13. **Documentation and references:**

**Detailed header comments?** No

**User guide or manual, technical reports, papers, books:**

NASA CR159142
14. **Approximate cost of obtaining software:** \$675.00
15. **Restrictions on use:** no
16. **Distributor:** COSMIC  
112 Barrow Hall, University of Georgia  
Athens, GA 30602
17. **Original source of software:**

**Developer:** Elizabeth Yip

**Institution:** Boeing Commercial Airplane Co.

**Sponsor:** NASA Langley Research Center
18. **For further information contact:**

Steve Horton  
COSMIC  
404 542-3265

**1. Name of program or package:** SPAR2PAS

**2. Descriptive title:** Sparse linear equation solver by 2-pass approach

**3. Problem domain:** Unsymmetric linear systems, reorder equations

**4. Method of solution:** P4, HP (hierarchical partitioning), Gaussian elimination

**5. Programming language:** FORTRAN, mostly ANSI with few exceptions

**6. Precision:** Single

**7. Portability:** Portable

**8. Other packages required:** None

**9. Mode of use:** Callable subroutines

**10. Test or demonstration program available?** No

**11. Length of code in lines:** ~ 4500      **Percentage comments:** 30%

**12. Special features:** Optionally, matrix is out-of-core, row at a time processing; reordering techniques especially suited for chemical process flowsheeting problems.

**13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:**

User guide forthcoming.

Mark A. Stadtherr and E. Steven Wood, "Sparse Matrix Methods for Equation Based Chemical Process Flowsheeting: I. Reordering Phase, II. Numerical Phase," preprints.

**14. Approximate cost of obtaining software:** Small fee

**15. Restrictions on use:** none

**16. Distributor:** Same as 18

**17. Original source of software:**

**Developer:** Mark A. Stadtherr

**Institution:** University of Illinois

**Sponsor:** NSF

**18. For further information contact:**

Mark A. Stadtherr  
Chemical Engineering Department  
University of Illinois  
1209 West California Street  
Urbana, Illinois 61801  
Phone: 217-333-0275

- 1. Name of program or package:** LINPACK
- 2. Descriptive title:** Dense linear equation solver
- 3. Problem domain:** Linear systems for general, banded, symmetric indefinite, symmetric positive definite, triangular and tridiagonal; plus QR and SVD for rectangular matrices.
- 4. Method of solution:** Direct matrix factorization
- 5. Programming language:** Fortran
- 6. Precision:** Single, double, complex and double complex
- 7. Portability:** Fully portable
- 8. Other packages required:** BLAS
- 9. Mode of use:** Callable subroutines
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 7000 lines in each precision **Percentage comments:** 50%
- 12. Special features:** Column orientation for efficiency.

**13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:**

LINPACK Users' Guide, J. J. Dongarra, J. R. Bunch, C. B. Moler, G. W. Stewart, SIAM Pub., Philadelphia, 1979.

**14. Approximate cost of obtaining software:** \$75 handling fee

**15. Restrictions on use:** None

**16. Distributor:** National Energy Software Center IMSL, Inc.  
Argonne National Laboratory Sixth Floor, NBC Building  
9700 South Cass Avenue 7500 Bellaire Boulevard  
Argonne, IL 60439 Houston, TX 77036

**17. Original source of software:**

**Developer:** Dongarra, Bunch, Moler, Stewart

**Institution:** Argonne National Laboratory, Univ. of California (San Diego), Univ.

**Sponsor:** of New Mexico, Univ. of Maryland

NSF & DOE

**18. For further information contact:**

Jack Dongarra  
Mathematics and Computer Science Div.  
Argonne National Laboratory  
Argonne, IL 60439  
(312) 972-7246

ARPA: ANLAMS!Dongarra@UCB-C70

1. **Name of program or package:** PROFILE/U/CRAY
2. **Descriptive title:** Unsymmetric Banded and Profile Solvers for the CRAY-1
3. **Problem domain:** Unsymmetric banded and profile matrices
4. **Method of solution:** LU factorization
5. **Programming language:** CRAY assembly language
6. **Precision:** 64-Bit
7. **Portability:** CRAY-1, CRAY-1S, CRAY X-MP
8. **Other packages required:** None
9. **Mode of use:** Subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 2700                      **Percentage comments:** 20
12. **Special features:** Compressed storage by rows or columns; no bandwidth restriction; achieves 100 MFLOPS with bandwidths greater than 40.
13. **Documentation and references:**
  - Detailed header comments?** No
  - User guide or manual, technical reports, papers, books:**
    - "High Performance Banded and Profile Solvers for the CRAY-1: The Unsymmetric Case" Report #160, Systems Engineering Laboratory, University of Michigan, Ann Arbor, MI 48109; February, 1982.
14. **Approximate cost of obtaining software:** Send user tape
15. **Restrictions on use:** None
16. **Distributor:** See Below
17. **Original source of software:**
  - Developer:** D.A. Calahan, Dept. of Elec. & Comp. Engineering
  - Institution:** University of Michigan, Ann Arbor, MI 48109; 313-763-0036
  - Sponsor:** Air Force Office of Scientific Research
18. **For further information contact:** See Above



- 1. Name of program or package:** SPAR/BL/CRAY
- 2. Descriptive title:** General Block-Oriented Sparse Solver for CRAY-1
- 3. Problem domain:** Unsymmetric matrices
- 4. Method of solution:** LU factorization
- 5. Programming language:** Fortran and CRAY Assembly Language
- 6. Precision:** 64-bit
- 7. Portability:** CRAY-1, CRAY-1S, CRAY X-MP
- 8. Other packages required:**
- 9. Mode of use:** Subroutine(s)
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 1800                      **Percentage comments:** 20
- 12. Special features:** Solves matrices blocked by row and column strips  
emanating from diagonal blocks.
- 13. Documentation and references:**  
**Detailed header comments?**  
**User guide or manual, technical reports, papers, books:**  
"A Collection of Sparse Matrix Solvers for the CRAY-1", Report  
#166, Systems Engineering Laboratory, University of Michigan,  
Ann Arbor, MI 48109; October, 1982
- 14. Approximate cost of obtaining software:** Send user tape
- 15. Restrictions on use:** None
- 16. Distributor:** See Below
- 17. Original source of software:**  
**Developer:** D.A. Calahan, Dept. of Elec. & Comp. Engineering  
**Institution:** University of Michigan, Ann Arbor, MI 48109  
**Sponsor:** Air Force of Scientific Research
- 18. For further information contact:** See Above

1. **Name of program or package:** SOLVEBLOK
2. **Descriptive title:** Direct almost block diagonal system solver
3. **Problem domain:** Almost block diagonal systems such as arise in spline approximation, e.g., in the pp collocation solution to ODE BVPs.
4. **Method of solution:** Gauss elimination with scaled partial pivoting
5. **Programming language:** Fortran V
6. **Precision:** single
7. **Portability:** developed on UNIVAC 1100, is running on various other machines
8. **Other packages required:** none
9. **Mode of use:** callable subroutine(s)
10. **Test or demonstration program available?** yes, part of package
11. **Length of code in lines:** 510                      **Percentage comments:** (297/510)\*100
12. **Special features:** none
13. **Documentation and references:**
  - Detailed header comments?** yes
  - User guide or manual, technical reports, papers, books:** ACM Trans.Math.Software 6(1980), 80-87; Algorithm 546, ACM Trans.Math.Software 6 (1980), 88-91.
14. **Approximate cost of obtaining software:** postage
15. **Restrictions on use:** none
16. **Distributor:** ACM Algorithms Distribution service (listing), or send tape to developer (see 18.)
17. **Original source of software:**
  - Developer:** C. de Boor & R. Weiss
  - Institution:** MRC, U.Wisconsin-Madison
  - Sponsor:**
18. **For further information contact:** C. de Boor, MRC, 610 Walnut St., Madison WI 53706

- 1. Name of program or package:** ARCECO
- 2. Descriptive title:** Almost block diagonal linear system solver
- 3. Problem domain:** Finite element methods for the solution of differential equations in one space variable.
- 4. Method of solution:** Modified alternate row and column elimination
- 5. Programming language:** ANSI Fortran
- 6. Precision:** Double (changes for single indicated)
- 7. Portability:** IBM 370/165, IBM 3033/N8, DEC-10. Easily portable
- 8. Other packages required:** None
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 1110 **Percentage comments:** 70%
- 12. Special features:** None

**13. Documentation and references:****Detailed header comments?** Yes**User guide or manual, technical reports, papers, books:**

J.C. Diaz, G. Fairweather and P. Keast FORTRAN packages for solving almost block diagonal linear systems by modified alternate row and column elimination, Technical Report 148/81, Department of Computer Science, University of Toronto.

**14. Approximate cost of obtaining software:** Free on submission of a tape.**15. Restrictions on use:** None

**16. Distributor:** Dr. P. Keast, Department of Computer Science, University of Toronto, Toronto, CANADA M5S 1A7

**17. Original source of software:**

**Developer:** J.C. Diaz, G. Fairweather, P. Keast  
**Institution:** University of Kentucky and University of Toronto  
**Sponsor:**

NSERC

**18. For further information contact:**

Dr. P. Keast, Department of Computer Science, University of Toronto,  
 Toronto, CANADA M5S 1A7

**1. Name of program or package:**

ROWCOL

**2. Descriptive title:**

Almost block diagonal linear system solver

**3. Problem domain:** $H^{-1}$ -Galerkin and collocation  $H^{-1}$ -Galerkin methods for differential equations in one space variable**4. Method of solution:**

Modified alternate row and column elimination

**5. Programming language:**

ANSI Fortran

**6. Precision:**

Double (changes for single indicated)

**7. Portability:**

IBM 370/165, IBM 3033/N8, DEC-10. Easily portable.

**8. Other packages required:**

None

**9. Mode of use:**

Callable subroutine

**10. Test or demonstration program available?**

Yes

**11. Length of code in lines:**

675

**Percentage comments:**

74%

**12. Special features:**

None

**13. Documentation and references:****Detailed header comments?**

Yes

**User guide or manual, technical reports, papers, books:**

G. Fairweather and P. Keast, ROWCOL - a program for solving almost block diagonal linear systems arising in the  $H^{-1}$ -Galerkin and collocation  $H^{-1}$ -Galerkin methods, Technical Report, Department of Computer Science, University of Toronto, to appear.

**14. Approximate cost of obtaining software:**

Free on submission of a tape.

**15. Restrictions on use:**

None

**16. Distributor:**

Dr. P. Keast, Department of Computer Science, University of Toronto,  
Toronto, Canada M5S 1A7

**17. Original source of software:****Developer:** G. Fairweather and P. Keast**Institution:** University of Kentucky and University of Toronto**Sponsor:**

NSERC

**18. For further information contact:**

Dr. P. Keast, Department of Computer Science, University of Toronto,  
Toronto, Canada M5S 1A7

**1. Name of program or package:** COLROW

**2. Descriptive title:** Almost block diagonal linear system solver

**3. Problem domain:** Finite element methods for the solution of differential equations in one space variable.

**4. Method of solution:** Modified alternate row and column elimination

**5. Programming language:**

ANSI Fortran

**6. Precision:**

**7. Portability:** Double (changes for single indicated)

IBM 370/165, IBM 3033/N8, DEC-10. Easily portable.

**8. Other packages required:** None

**9. Mode of use:** Callable subroutine

**10. Test or demonstration program available?** Yes

**11. Length of code in lines:** 1120 **Percentage comments:** 65%

**12. Special features:**

None

**13. Documentation and references:**

**Detailed header comments?** yes

**User guide or manual, technical reports, papers, books:**

J.C.Diaz, G. Fairweather, and P. Keast, FORTRAN packages for solving almost block diagonal linear systems by modified alternate row and column elimination, Technical Report 148/81, Department of Computer Science, University of Toronto.

**14. Approximate cost of obtaining software:** Free on submission of a tape.

**15. Restrictions on use:** None

**16. Distributor:** Dr. P. Keast, Department of Computer Science, University of Toronto, Toronto, CANADA M5S 1A7

**17. Original source of software:**

**Developer:** G. Fairweather and P. Keast

**Institution:** University of Kentucky and University of Toronto

**Sponsor:**

NSERC

**18. For further information contact:**

Dr. P. Keast, Computer Science Department, University of Toronto, Toronto, Canada M5S 1A7

1. **Name of program or package:** MA27
2. **Descriptive title:** Solves linear sets of equations.
3. **Problem domain:** Sparse symmetric matrices, which need not be definite.
4. **Method of solution:** Symmetric factorization, including 2\*2 pivots.
5. **Programming language:** IBM Fortran.
6. **Precision:** Both single and double precision versions are available.
7. **Portability:** Fortran 66 version available.
8. **Other packages required:** None.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 2922 **Percentage comments:** 37%
12. **Special features:** Multi-frontal approach, with vectorizable inner loops. Complex version (ME27) available.
13. **Documentation and references:**  
**Detailed header comments?** Yes.  
**User guide or manual, technical reports, papers, books:**  
Harwell Subroutine Library Specification Document.  
I.S.Duff and J.K.Reid (1982), The multifrontal solution of indefinite sparse symmetric linear systems. To appear.  
I.S.Duff and J.K.Reid (1982), MA27 – A set of Fortran subroutines for solving symmetric sets of linear equations. Harwell report R-10533, H.M.S.O., London.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (i), (ii), (iii), (iv) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell, Oxfordshire OX11 0RA, England.
17. **Original source of software:**  
**Developer:** I.S.Duff and J.K.Reid.  
**Institution:** A.E.R.E. Harwell.  
**Sponsor:** A.E.R.E. Harwell.
18. **For further information contact:** The developers.

**1. Name of program or package:** SPARSPAK

**2. Descriptive title:** Solution of Sparse Systems of Linear Equations

**3. Problem domain:** Systems of Equations having symmetric structure and for which no pivoting for stability is required; symmetric positive definite systems.

**4. Method of solution:**

Cholesky's method, Gaussian elimination

**5. Programming language:**

FORTRAN

**6. Precision:** SINGLE OR DOUBLE

**7. Portability:** Runs through PFORT; special IBM versions also available.

**8. Other packages required:** None

**9. Mode of use:** Sets of sub-routines - callable from Fortran user program.

**10. Test or demonstration program available?** Yes

**11. Length of code in lines:**

**Percentage comments:**

Approx. 20,000

Approx. 20%

**12. Special features:**

- friendly user interface
- easy to use SAVE and RESTART facility.

**13. Documentation and references:**

**Detailed header comments?** No

**User guide or manual, technical reports, papers, books:**

- User Guide for SPARSPAK: Waterloo Sparse Linear Equations Package, Alan George, Joseph Liu, and Esmond Ng.
- Book: Computer Solution of Large Sparse Positive Definite Systems, Alan George and Joseph Liu, Prentice Hall, Inc., March 1981.

**14. Approximate cost of obtaining software:** US\$750.00 (one time charge for source code).

**15. Restrictions on use:** license agreement required

**16. Distributor:**

Waterloo Research Institute  
University of Waterloo  
Waterloo, Ontario, CANADA N2L 3G1

**17. Original source of software:**

**Developer:** Alan George and Joseph Liu

**Institution:** University of Waterloo

**Sponsor:** 1) Natural Sciences and Engineering Council of Canada  
2) University of Waterloo

**18. For further information contact:**

Prof. Alan George  
Dept. of Computer Science  
University of Waterloo  
Waterloo, Ontario, CANADA N2L 3G1.

- 1. Name of program or package:** YSMP
- 2. Descriptive title:** Yale Sparse Matrix Package
- 3. Problem domain:** Re-ordering, Factorization and Solution of Symmetric and nonsymmetric linear equations
- 4. Method of solution:** Minimum degree ordering and Sparse Gaussian Elimination
- 5. Programming language:** Fortran
- 6. Precision:** Single (marked, simple conversion to double)
- 7. Portability:** Developed on DEC-10, DEC-20, IBM/360, IBM/370, CDC-6600  
Easily portable to other machines.
- 8. Other packages required:** None
- 9. Mode of use:** Callable subroutines (5 drivers + lower level subroutines)
- 10. Test or demonstration program available?** Yes (2)
- 11. Length of code in lines:** 4000      **Percentage comments:** 59%
- 12. Special features:** None
- 13. Documentation and references:**  
**Detailed header comments?** Yes  
**User guide or manual, technical reports, papers, books:**  
 S. C. Eisenstat, M. C. Gursky, M. H. Schultz, and A. H. Sherman, Yale Sparse Matrix Package I: The Symmetric Codes, Int. J. Num. Mthds Engrg, to appear.  
 S. C. Eisenstat, M. C. Gursky, M. H. Schultz, and A. H. Sherman, Yale Sparse Matrix Package II: The Nonsymmetric Codes, Report 114, Dept. of Computer Science, Yale University, 1977.
- 14. Approximate cost of obtaining software:** \$100.00
- 15. Restrictions on use:** None
- 16. Distributor:** YSMP Librarian  
 Department of Computer Science  
 Box 2158 Yale Station  
 New Haven, Conn. 06520
- 17. Original source of software:**  
**Developer:**  
**Institution:** Stanley C. Eisenstat, Martin H. Schultz, Andrew H. Sherman  
 Yale University  
**Sponsor:** ONR, AFOSR
- 18. For further information contact:**  
 Stanley C. Eisenstat  
 Department of Computer Science  
 Box 2158 Yale Station  
 New Haven, CT 06520  
 713/432-4674



- 1. Name of program or package:** General Symmetric Sparse Solver (Symmetric SYMFAC, NUMFAC and BKSLVE)
- 2. Descriptive title:** Symmetric sparse linear systems solver
- 3. Problem domain:** Symmetric positive definite linear systems
- 4. Method of solution:** SYMFAC - NUMFAC approach
- 5. Programming language:** FORTRAN
- 6. Precision:** Single and double precision
- 7. Portability:** Standard FORTRAN
- 8. Other packages required:** None
- 9. Mode of use:** Callable FORTRAN subroutines
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** about 500      **Percentage comments:** about 50%
- 12. Special features:**
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - Some Results on Sparse Matrices, IBM Research Report 1980
    - "Some Basic Techniques for Solving Sparse Systems of Linear Equations,"
    - Sparse Matrices and their Applications, D. J. Rose and R. A. Willoughby
    - (eds.) Plenum Press, 1972, pp. 41-52
- 14. Approximate cost of obtaining software:** See 18.
- 15. Restrictions on use:** None
- 16. Distributor:** Same as 18.
- 17. Original source of software:**
  - Developer:** Fred G. Gustavson
  - Institution:** IBM Research
  - Sponsor:**
- 18. For further information contact:**
  - Dr. Fred G. Gustavson 33-205
  - IBM T. J. Watson Research Center
  - P.O. Box 218
  - Yorktown Heights, New York 10598
  - Phone: (914) 945-1980

1. **Name of program or package:** RSFS
2. **Descriptive title:** Sparse linear system solver
3. **Problem domain:** Real, symmetric linear systems
4. **Method of solution:** LDU Decomposition
5. **Programming language:** FPS-164 Array Processor
6. **Precision:** 64-bit word
7. **Portability:** Developed for the FPS-164 Array Processor. A version also exists for the following FPS 38-bit Array Processors:  
FPS-100, AP-120B, AP-180V, and AP-190L.
8. **Other packages required:** FPS-164 Math Library (APMATH64)
9. **Mode of use:** Callable subroutine
10. **Test or demonstration program available?** No
11. **Length of code in lines:** 1112                      **Percentage comments:** 70
12. **Special features:** Takes advantage of the parallel, pipelined architecture of the FPS-164 Array Processor.
13. **Documentation and references:**  
     **Detailed header comments?** Yes  
     **User guide or manual, technical reports, papers, books:**  
     APMATH64 Reference Manual  
     Floating Point Systems, Inc.
14. **Approximate cost of obtaining software:** This routine is included in the FPS-164 Math Library (APMATH64).
15. **Restrictions on use:** License agreement required
16. **Distributor:** Floating Point Systems, Inc.  
     P.O. Box 23489  
     Portland, Or. 97223  
     (503) 641-3151
17. **Original source of software:**  
     **Developer:** Ron Coleman  
     **Institution:** Floating Point Systems, Inc.  
     **Sponsor:** Floating Point Systems, Inc.
18. **For further information contact:**  
     Phil Vaughn  
     Floating Point Systems, Inc  
     P.O. Box 23489  
     Portland, OR 97223  
     (503) 641-3151      TLX: 360470    FLOATPOIN BEAV

**1. Name of program or package:** CSPARSPAK

**2. Descriptive title:** Complex version of sparse linear system solver, SPARSPAK.

**3. Problem domain:** Large sparse complex systems of linear equations; most efficient for symmetric or Hermitian matrices.

**4. Method of solution:** Choice of 5 reordering algorithms followed by sparse Gaussian elimination.

**5. Programming language:** FORTRAN

**6. Precision:** Single

**7. Portability:** Developed on CYBER, IBM; portable.

**8. Other packages required:** SPARSPAK

**9. Mode of use:** Collection of subroutines.

**10. Test or demonstration program available?** Yes

**11. Length of code in lines:** 9000 lines      **Percentage comments:** about 50%

**12. Special features:** User insulated from complicated data structures and storage management.

**13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:** SPARSPAK User Guide

**14. Approximate cost of obtaining software:** CSPARSPAK is available to BCS network users. Possibility of sale to interested organizations is under review.

**15. Restrictions on use:** Use on BCS systems or if sold, internal use only. May not be distributed to others.

**16. Distributor:** Boeing Computer Services Company

**17. Original source of software:**

**Developer:** J.G. Lewis modified SPARSPAK (developed by Alan George & Joseph Liu).

**Institution:** Boeing Computer Services Company

**Sponsor:** Boeing Computer Services Company

**18. For further information contact:** J.G. Lewis  
Boeing Computer Services Company  
565 Andover Park West, MS 9C-01  
Tukwila, WA 98188  
(206) 575-5102

1. **Name of program or package:** CSFS
2. **Descriptive title:** Sparse linear system solver
3. **Problem domain:** Complex, symmetric linear systems
4. **Method of solution:** LDU Decomposition
5. **Programming language:** Assembly language - FPS-164 Array Processor
6. **Precision:** 64-bit word
7. **Portability:** Developed for the FPS-164 Array Processor. A version also exists for the following FPS 38-bit Array Processors:  
FPS-100, AP-120B, AP-180V, and AP-190L.
8. **Other packages required:** FPS-164 Math Library (APMATH64)
9. **Mode of use:** Callable subroutine
10. **Test or demonstration program available?** No
11. **Length of code in lines:** 1421                      **Percentage comments:** 71
12. **Special features:** Takes advantage of the parallel, pipelined architecture of the FPS-164 Array Processor.
13. **Documentation and references:**  
     **Detailed header comments?** Yes  
     **User guide or manual, technical reports, papers, books:**  
     APMATH64 Reference Manual  
     Floating Point Systems, Inc.
14. **Approximate cost of obtaining software:** This routine is included in the FPS-164 Math Library (APMATH64).
15. **Restrictions on use:** License agreement required.
16. **Distributor:** Floating Point Systems, Inc.  
     P.O. Box 23489  
     Portland, OR 97223            (503) 641-3151
17. **Original source of software:**  
     **Developer:** Ron Coleman  
     **Institution:** Floating Point Systems, Inc.  
     **Sponsor:** Floating Point Systems, Inc.
18. **For further information contact:**  
     Phil Vaughn  
     Floating Point Systems, Inc.  
     P.O. Box 23489  
     Portland, OR 97223  
     (503) 641-3151    TLX: 360470    FLOATPOIN    BEAV

**1. Name of program or package:** FO1MCF

**2. Descriptive title:** Factorises a matrix

**3. Problem domain:** Symmetric, positive definite, variable bandwidth matrix

**4. Method of solution:** Cholesky

**5. Programming language:** FORTRAN

**6. Precision:** Either

**7. Portability:** Available on 48 machine ranges/compilers

**8. Other packages required:** NAG

**9. Mode of use:** Callable subroutine

**10. Test or demonstration program available?** Yes

**11. Length of code in lines:** 126 **Percentage comments:** 54%

**12. Special features:**

**13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:**

NAG Library Manual

NAG On-line Supplement

**14. Approximate cost of obtaining software:** NAG Library costs \$1584/year

**15. Restrictions on use:** License agreement

**16. Distributor:** NAG (U.S.A.) Inc.  
(see below)

**17. Original source of software:**

**Developer:** Dr. M. Cox

**Institution:** N.P.L.

**Sponsor:** NAG

**18. For further information contact:**

Mrs. Carolyn M. Smith

NAG (U.S.A.) Inc.

1250 Grace Court

Downers Grove, IL 60516

Tel. 971-2337

Telex 23254708 (Teleserv DFLD)

- 1. Name of program or package:** F04MCF
- 2. Descriptive title:** Solves a system of linear algebraic equations
- 3. Problem domain:** Symmetric, positive-definite variable bandwidth matrix
- 4. Method of solution:** Cholesky
- 5. Programming language:** FORTRAN
- 6. Precision:** Either
- 7. Portability:** Available on 48 machine ranges/compilers
- 8. Other packages required:** NAG
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 155      **Percentage comments:** 76%
- 12. Special features:**
- 13. Documentation and references:**  
**Detailed header comments?** Yes  
**User guide or manual, technical reports, papers, books:**  
NAG Library Manual  
NAG On-line Supplement
- 14. Approximate cost of obtaining software:** NAG Library License costs \$1584/year
- 15. Restrictions on use:** License agreement
- 16. Distributor:** NAG (U.S.A.) Inc.  
(see below)
- 17. Original source of software:**  
**Developer:** Dr. M. Cox  
**Institution:** N.P.L.  
**Sponsor:** NAG
- 18. For further information contact:**  
Mrs. Carolyn M. Smith  
NAG (U.S.A.) Inc.  
1250 Grace Court  
Downers Grove, IL 60516  
Tel. 971-2337  
Telex 23254708 (Telexerv DFLD)

1. **Name of program or package:** MA15
2. **Descriptive title:** Solve linear sets of equations.
3. **Problem domain:** Symmetric positive-definite banded matrices.
4. **Method of solution:** Symmetric factorization.
5. **Programming language:** IBM Fortran.
6. **Precision:** Both single and double precision versions are available.
7. **Portability:** Fortran 77 version available.
8. **Other packages required:** Harwell subroutine FM01.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 147 **Percentage comments:** 4%  
(252 with dependencies)
12. **Special features:** Overflows to direct-access file if necessary.
13. **Documentation and references:**  
Detailed header comments? No.  
**User guide or manual, technical reports, papers, books:**  
Harwell Subroutine Library Specification Document.  
J.K.Reid (1972), Two Fortran subroutines for direct solution of linear equation whose matrix is sparse, symmetric and positive definite. Harwell report R.7119, H.M.S.O., London.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell, Oxfordshire OX11 0RA, England.
17. **Original source of software:**  
**Developer:** J.K.Reid.  
**Institution:** A.E.R.E. Harwell.  
**Sponsor:** A.E.R.E. Harwell.
18. **For further information contact:** The developer.

1. **Name of program or package:** PROFILE/S/CRAY
2. **Descriptive title:** Symmetric Banded and Profile Solvers for the CRAY-1
3. **Problem domain:** Symmetric banded and profile matrices
4. **Method of solution:**  $U^T DU$  factorization
5. **Programming language:** CRAY assembly language
6. **Precision:** 64-bit
7. **Portability:** CRAY-1, CRAY-1S, CRAY X-MP
8. **Other packages required:** None
9. **Mode of use:** Subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 2500                      **Percentage comments:** 20
12. **Special features:** Compressed storage by rows or columns; no bandwidth restriction; achieves 120 MFLOPS with bandwidth greater than 40.
13. **Documentation and references:**  
    **Detailed header comments?** No  
    **User guide or manual, technical reports, papers, books:**  
    "High Performance Banded and Profile Solvers for the CRAY-1:  
    The Symmetric Case" Report #165, Systems Engineering Laboratory,  
    University of Michigan, Ann Arbor, MI 48109; August 1982.
14. **Approximate cost of obtaining software:** Send user tape
15. **Restrictions on use:** None
16. **Distributor:** See Below
17. **Original source of software:**  
    **Developer:** D.A. Calahan, Dept. of Elec. & Comp. Engineering  
    **Institution:** University of Michigan, Ann Arbor, MI 48109; 313-763-0036  
    **Sponsor:** Air Force Office of Scientific Research
18. **For further information contact:** See Above



1. **Name of program or package:** SKYSOL
2. **Descriptive title:** Sparse linear system solver
3. **Problem domain:** Real, symmetric, skyline profile linear systems
4. **Method of solution:** LU Decomposition
5. **Programming language:** Assembly Language - FPS-164 Array Processor
6. **Precision:** 64-bit word
7. **Portability:** Developed for the FPS-164 Array Processor. A version also exists for the following FPS 38-bit Array Processors: FPS-100, AP-120B, AP-180V, and AP-190L.
8. **Other packages required:** FPS-164 Math Library (APMATH64)
9. **Mode of use:** Callable subroutine
10. **Test or demonstration program available?** No
11. **Length of code in lines:** 576                      **Percentage comments:** 50
12. **Special features:** Takes advantage of the parallel, pipelined architecture of the FPS-164 Array Processor.
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - APMATH64 Reference Manual
    - Floating Point Systems, Inc.
14. **Approximate cost of obtaining software:** This routine is included in the FPS-164 Math Library (APMATH64).
15. **Restrictions on use:** License agreement required
16. **Distributor:** Floating Point Systems, Inc.
  - P.O. Box 23489
  - Portland, OR 97223
  - (503) 641-3151
17. **Original source of software:**
  - Developer:** L. Tarvestad
  - Institution:** Floating Point Systems, Inc.
  - Sponsor:** Floating Point Systems, Inc.
18. **For further information contact:**
  - Phil Vaughn
  - Floating Point Systems, Inc.
  - P.O. Box 23489
  - Portland, OR 97223
  - (503) 641-3151    TLX: 360470    FLOATPOIN BEAV

1. **Name of program or package:** ITPACK 2C
2. **Descriptive title:** Sparse linear system solver using iterative methods
3. **Problem domain:** The seven ITPACK routines can be called with any linear system containing positive diagonal elements, however they are most successful in solving systems with symmetric positive definite or mildly nonsymmetric matrices.
4. **Method of solution:** Jacobi Conjugate Gradient, Jacobi Semi-iteration, SOR, Symmetric SOR Conjugate Gradient, Symmetric SOR semi-iteration, Reduced System Conjugate Gradient, Reduced System Semi-iteration
5. **Programming language:**  
ANSI FORTRAN 66
6. **Precision:** Single
7. **Portability:** Easily portable since entire package written in ANSI FORTRAN 66.  
Was developed on a CDC CYBER 170/750 but tested on other computers.
8. **Other packages required:** None
9. **Mode of use:** Callable subroutines
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 8960      **Percentage comments:** 51%
12. **Special features:** Uses sparse storage scheme (symmetric or nonsymmetric). Automatic selection of the acceleration parameters and the use of accurate stopping criteria are major features of this software package.
13. **Documentation and references:**  
**Detailed header comments?** Yes  
**User guide or manual, technical reports, papers, books:**  
 "ITPACK 2C: A Fortran Package for Solving Large Sparse Linear Systems by Adaptive Accelerated Iterative Methods", David R. Kincaid, John R. Respass, David M. Young, and Roger G. Grimes, ACM Transactions on Mathematical Software, Vol. 8, No. 3, September 1982.  
Applied Iterative Methods, Louis A. Hageman and David M. Young, Academic Press, 1981.
14. **Approximate cost of obtaining software:** Mag. Tape \$76.50 ACM Member; \$90 Others
15. **Restrictions on use:** None
16. **Distributor:** ACM ALGORITHMS DISTRIBUTION SERVICE  
International Mathematical and Statistical Libraries, Inc.  
Sixth Floor, NBC Building, 7500 Bellaire Boulevard  
Houston, Texas 77036 (713) 772-1927
17. **Original source of software:**  
**Developer:** David R. Kincaid, Roger G. Grimes, John R. Respass, David M. Young  
**Institution:** Center for Numerical Analysis, University of Texas at Austin  
**Sponsor:** National Science Foundation
18. **For further information contact:** John R. Respass, Center for Numerical Analysis  
University of Texas at Austin  
RLM 13.150  
Austin, Texas 78712  
(512) 471-1242  
  
ARPANET: RESPASS@UTEXAS-11

- 1. Name of program or package:** SITSOL
- 2. Descriptive title:** Sparse linear system solver
- 3. Problem domain:** Real, unsymmetric linear systems
- 4. Method of solution:** SOR or Gauss-Seidel
- 5. Programming language:** Assembly language - FPS-164 Array Processor
- 6. Precision:** 64-bit word
- 7. Portability:** Developed for the FPS-164 Array Processor.
- 8. Other packages required:** FPS-164 Math Library (APMATH64)
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** No
- 11. Length of code in lines:** 742 **Percentage comments:** 77
- 12. Special features:** Takes advantage of the parallel, pipelined architecture of the FPS-164 array processor.
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**  
APMATH64 Reference Manual  
Floating Point Systems, Inc.
- 14. Approximate cost of obtaining software:** This routine is included in the FPS-164 Math Library (APMATH64)
- 15. Restrictions on use:** License agreement required
- 16. Distributor:** Floating Point Systems, Inc.  
P.O. Box 23489  
Portland, OR 97223  
(503) 641-3151
- 17. Original source of software:**
  - Developer:** Ron Coleman
  - Institution:** Floating Point Systems, Inc.
  - Sponsor:** Floating Point Systems, Inc.
- 18. For further information contact:**
  - Phil Vaughn
  - Floating Point Systems, Inc.
  - P.O. Box 23489
  - Portland, OR 97223
  - (503) 641-3151 TLX: 360470 FLOATPOIN BEAV

1. **Name of program or package:** TCHLIB
2. **Descriptive title:** Sparse Linear System Solver
3. **Problem domain:** Symmetric and Nonsymmetric Linear Systems
4. **Method of solution:** Tchebychev iteration with Dynamic Estimation of Parameters
5. **Programming language:** FORTRAN
6. **Precision:** Single
7. **Portability:** Passes PFORT Verifier
8. **Other packages required:** BLAS, EISPACK
9. **Mode of use:** Subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 2734      **Percentage comments:** 40%
12. **Special features:** Highly vectorized
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:** None
14. **Approximate cost of obtaining software:** None
15. **Restrictions on use:** None
16. **Distributor:** NESC
17. **Original source of software:**
  - Developer:** T. A. Manteuffel
  - Institution:** Los Alamos National Laboratory
  - Sponsor:** DOE
18. **For further information contact:**
  - T. A. Manteuffel
  - Mail Stop B265
  - Los Alamos National Laboratory
  - Los Alamos, NM 87545

- 1. Name of program or package:** SYMMLQ
- 2. Descriptive title:** Sparse linear system solver
- 3. Problem domain:** Symmetric systems, definite or indefinite
- 4. Method of solution:** Lanczos tridiagonalization
- 5. Programming language:** ANSI FORTRAN
- 6. Precision:** Single, easily converted to double
- 7. Portability:** Developed on IBM and Burroughs;  
easily portable to other machines
- 8. Other packages required:** BLAS if available; simplified alternatives provided
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 500                      **Percentage comments:** 60%
- 12. Special features:** BLAS operations are efficient in a paging environment and on pipeline machines.  
Overall efficiency may depend on user's own routine for computing matrix-vector products  $y = Ax$ .
- 13. Documentation and references:**  
**Detailed header comments?** Yes  
**User guide or manual, technical reports, papers, books:**  
 Paper: C.C. Paige and M.A. Saunders, "Solution of sparse indefinite systems of linear equations", SIAM Journal of Numerical Analysis, Vol. 12, No. 4, September 1975, 617-629.
- 14. Approximate cost of obtaining software:** Zero, if tape is returned after use.
- 15. Restrictions on use:** None
- 16. Distributor:** Michael Saunders                      Ph: (415)497-1875  
 Department of Operations Research  
 Stanford University, Stanford, CA 94305
- 17. Original source of software:**  
**Developer:** Chris Paige                      Michael Saunders  
**Institution:** McGill University              Stanford University  
**Sponsor:** National Research Council of Canada; DSIR, New Zealand;  
 AEC, NSF.
- 18. For further information contact:**  
 Michael Saunders (see 16 above)

- 1. Name of program or package:** ICCG-package
- 2. Descriptive title:** Mathematical software for elliptic boundary value problems.
- 3. Problem domain:** Self-adjoint/mixed, periodic boundary conditions/2 D rectangular domains.
- 4. Method of solution:** Standard finite differences with conjugate gradient iteration technique, preconditioned with incomplete Choleski factorization.
- 5. Programming language:** FORTRAN (ANSI)
- 6. Precision:** Single
- 7. Portability:** Portable FORTRAN (PFORT verifier); tested on Cyber 175-28 (CDC)
- 8. Other packages required:** None
- 9. Mode of use:** Callable subroutines
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** ca. 3000      **Percentage comments:** over 50%
- 12. Special features:**  
Versions for space or time economization
- 13. Documentation and references:** Available  
**Detailed header comments?** Yes  
**User guide or manual, technical reports, papers, books:**  
J. M. van Kats & H. A. van der Vorst, "Software for the discretisation and solution of second order self-adjoint elliptic partial differential equations in two dimensions,": TR-10, ACCU, Budapestlaan 6, Utrecht, The Netherlands
- 14. Approximate cost of obtaining software:** Free
- 15. Restrictions on use:** None
- 16. Distributor:** ACCU, Budapestlaan 6, Utrecht, The Netherlands
- 17. Original source of software:** A.C.C.U.  
**Developer:** Jan van Kats & Henk van der Vorst  
**Institution:** Academic Computer Centre Utrecht  
**Sponsor:** Utrecht University
- 18. For further information contact:**  
Henk van der Vorst  
ACCU  
Budapestlaan 6  
Utrecht  
The Netherlands

1. **Name of program or package:** MA31
2. **Descriptive title:** Solves linear sets of equations.
3. **Problem domain:** Symmetric sparse positive-definite matrices.
4. **Method of solution:** Incomplete factorization and conjugate gradients.
5. **Programming language:** IBM Fortran.
6. **Precision:** Both single and double precision versions are available.
7. **Portability:** Fortran 66 version available.
8. **Other packages required:** None.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 1111 **Percentage comments:** 35%
12. **Special features:** Contains a parameter to adjust the amount of fill. It can therefore be used as a direct solver with iterative refinement or as an iterative solver requiring a variable amount of storage.
13. **Documentation and references:**
  - Detailed header comments?** Yes.
  - User guide or manual, technical reports, papers, books:**
    - Harwell Subroutine Library Specification Document.
    - N. Munksgaard (1980) Solving sparse symmetric sets of linear equations by preconditioned conjugate gradients. A.C.M. Trans. Math. Software, **6**, 206-219.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell, Oxfordshire OX11 0RA, England.
17. **Original source of software:**
  - Developer:** N.Munksgaard.
  - Institution:** Technical University of Denmark.
  - Sponsor:** Danish Natural Science Research Council.
18. **For further information contact:** I.S.Duff or J.K.Reid at Harwell.

**1. Name of program or package:**

PCGPAK

**2. Descriptive title:**

Sparse linear system solver.

**3. Problem domain:**

General nonsingular sparse linear systems.

**4. Method of solution:**

Preconditioned conjugate gradient method and conjugate gradient-like iterative methods.

**5. Programming language:**

FORTRAN

**6. Precision:**

Either

**7. Portability:**

Developed on DEC-20 and VAX-780. Easily portable.

**8. Other packages required:**

BLAS

**9. Mode of use:**

Callable subroutine.

**10. Test or demonstration program available?**

NO

**11. Length of code in lines:**

length 2700

**Percentage comments:**

percentage 30%

**12. Special features:**

None

**13. Documentation and references:****Detailed header comments?****User guide or manual, technical reports, papers, books:**

S. C. Eisenstat, H. C. Elman, M. H. Schultz.

Variational iterative methods for nonsymmetric systems of linear equations. Technical Report #209, Yale University, Dept. of Computer Science, 1981.

**14. Approximate cost of obtaining software:****15. Restrictions on use:**

Software not available for distribution at present.

**16. Distributor:****17. Original source of software:** Howard C. Elman, Stanley C. Eisenstat, Martin H. Schultz**Developer:****Institution:** Yale University, Dept. of Computer Science**Sponsor:** ONR, NSF, Scientific Computing Associates**18. For further information contact:**

Howard C. Elman  
Yale Univ. Dept. of Computer Science  
P.O. Box 2158 Yale Station  
New Haven, CT 06520

(203) 432-4674



**1. Name of program or package:** CG25, BCG25, CCG25.

**2. Descriptive title:** Packages for solving five diagonal systems of algebraic equations.

**3. Problem domain:** Solves systems of five diagonal systems of equations such as arise in finite difference models of two dimensional elliptic partial differential equations. CG is for symmetric systems, BCG for unsymmetric systems and CCG for complex systems.

**4. Method of solution:**

Preconditioned Conjugate Gradients.

**5. Programming language:** ANSI FORTRAN 66.

**6. Precision:** Single and double precision versions available.

**7. Portability:** Developed on IBM, but written in ANSI FORTRAN.

**8. Other packages required:** None

**9. Mode of use:** Callable subroutine.

**10. Test or demonstration program available?** Yes

**11. Length of code in lines:** About 2000 each **Percentage comments:** About 70%

**12. Special features:** Written for computational efficiency and for ease of modification and further enhancement. Hence the development of specialized versions for very large problems, for example, which use particular features of a computer, is made as easy as possible.

**13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:**

Program Note RD/L/2234 P81: CG25, BCG25, CCG25: Packages for solving five diagonal systems of algebraic equations using preconditioned conjugate gradient methods. Author: D.A.H. Jacobs, Central Electricity Research Laboratories, Leatherhead, Surrey, England.

**14. Approximate cost of obtaining software:** On application

**15. Restrictions on use:** License Agreement Required

**16. Distributor:** External Sales, Headquarters Computing Centre, Central Electricity Generating Board, 85 Park Street, London, SE1 9DY, England, Tele. 01 248 1202.

**17. Original source of software:**

**Developer:** D.A.H. Jacobs

**Institution:** Central Electricity Research Labs., Leatherhead, Surrey, England.

**Sponsor:** Central Electricity Generating Board

**18. For further information contact:** For sales: Mr. M. Wall (address in 16 above)

Technical Queries: Dr. D.A.H. Jacobs, Central Electricity Research Labs., Kelvin Avenue, Leatherhead, Surrey, England, Tele. 0372 374488

- 1. Name of program or package:** CG37, BCG37, CCG37.
- 2. Descriptive title:** Packages for solving seven diagonal systems of algebraic equations.
- 3. Problem domain:** Solves systems of seven diagonal systems of equations such as arise in finite difference models of three dimensional elliptic partial differential equations. CG is for symmetric systems, BCG for unsymmetric systems and CCG for complex systems
- 4. Method of solution:** Preconditioned Conjugate Gradients
- 5. Programming language:** ANSI FORTRAN 66
- 6. Precision:** Single and double precision versions available.
- 7. Portability:** Developed on IBM, but written in ANSI FORTRAN.
- 8. Other packages required:** None
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** About 2000 each **Percentage comments:** About 70%
- 12. Special features:** Written for computational efficiency and for ease of modification and further enhancement. Hence the development of specialized versions for very large problems, for example which use particular features of a computer, is made as easy as possible.
- 13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:**  
 Program Note RD/L/2235 P81: CG37, BCG37, CCG37: Packages for solving seven diagonal systems of algebraic equations using preconditioned conjugate gradient methods. Author: D.A.H. Jacobs, Central Electricity Research Laboratories, Leatherhead, Surrey, England.
- 14. Approximate cost of obtaining software:** On application
- 15. Restrictions on use:** License agreement required
- 16. Distributor:** External Sales, Headquarters Computing Centre, Central Electricity Generating Board, 85 Park Street, London, SE1 9DY, England, Tele. 01 248 1202.
- 17. Original source of software:**

**Developer:** D.A.H. Jacobs  
**Institution:** Central Electricity Research Labs., Leatherhead, Surrey, England  
**Sponsor:** Central Electricity Generating Board
- 18. For further information contact:** For sales: Mr. M. Wall (address in 16 above)  
 Technical Queries: Dr. D.A.H. Jacobs, Central Electricity Research Labs., Kelvin Avenue, Leatherhead, Surrey, England, Tele. 0372 374488

- 1. Name of program or package:** CGS, BCGS, CCGS
- 2. Descriptive title:** Sparse code packages for solving general irregular systems of algebraic equations.
- 3. Problem domain:** Solves systems of equations whose matrices are irregular (i.e. non-banded) such as arise for example from finite element formulations of elliptic partial differential equations. CGS is for symmetric systems. BCGS for unsymmetric systems, and CCGS for general complex systems
- 4. Method of solution:** Preconditioned Conjugate Gradients
- 5. Programming language:** ANSI FORTRAN 66
- 6. Precision:** Single and double precision versions available
- 7. Portability:** Developed on IBM but written in ANSI FORTRAN
- 8. Other packages required:** None
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** CGS approx 1500, BCGS/CCGS approx 2000  
**Percentage comments:** Approx. 75%
- 12. Special features:** Written for computational efficiency and for ease of modification and further enhancement (modular approach, fully internally documented).
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:** Program Note to be published, A user's guide to CGS, BCGS and CCGS: sparse code packages using preconditioned conjugate gradient methods for solving systems of algebraic equations. Author: G. Markham
- 14. Approximate cost of obtaining software:** On application
- 15. Restrictions on use:** License agreement required
- 16. Distributor:** External Sales, Headquarters Computing Centre, Central Electricity Generating Board, 85 Park Street, London, SE1 9DY, England. Tele 01 248 1202
- 17. Original source of software:**
  - Developer:** G. Markham
  - Institution:** Central Electricity Research Laboratories
  - Sponsor:** Central Electricity Generating Board
- 18. For further information contact:** Sales: (Mr. M. Wall (address as for 16 above)  
Technical queries: G. Markham, Central Electricity Research Laboratories  
Kelvin Avenue, Leatherhead, Surrey, England, KT22 7SE.  
Tele: 0372 374488

**1. Name of program or package:** DI205, DI3707, DI209, DI213

**2. Descriptive title:** Subroutines to solve a five, seven, nine and thirteen diagonal system of algebraic equations.

**3. Problem domain:** Solves systems of multi-diagonal systems of equations such as arise in finite difference models of partial differential equations. Five, nine and thirteen point molecules in two dimensions, and seven point in three dimensions can be used. Extensions to cover small perturbations on these structures can be employed.

**4. Method of solution:** Stone's Strongly Implicit Procedure

**5. Programming language:** ANSI FORTRAN 66

**6. Precision:** Single and double precision versions available.

**7. Portability:** Developed on IBM, but written in ANSI FORTRAN.

**8. Other packages required:** None

**9. Mode of use:** Callable subroutine

**10. Test or demonstration program available?** Yes

**11. Length of code in lines:** About 2000 each **Percentage comments:** About 70%

**12. Special features:** Written for computational efficiency and for ease of modification and further enhancement. Hence the development of specialized versions for very large problems, for example which use particular features of a computer, is made as easy as possible.

**13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:**

Program Notes: RD/L/P9/79: DI205; RD/L/P11/79: DI307; RD/L/P14/79: DI209;  
RD/L/P18/79: DI213. Author: D.A.H. Jacobs, Central Electricity  
Research Laboratories, Leatherhead, Surrey, England

**14. Approximate cost of obtaining software:** On application

**15. Restrictions on use:** License agreement required

**16. Distributor:** External Sales, Headquarters Computing Centre, Central  
Electricity Generating Board, 85 Park Street, London, SE1 9DY, England,  
Tele. 01 248 1202.

**17. Original source of software:**

**Developer:** D.A.H. Jacobs

**Institution:** Central Electricity research Labs., Leatherhead, Surrey, England

**Sponsor:** Central Electricity Generating Board

**18. For further information contact:** For sales: Mr. M. Wall (address in 16 above)

Technical Queries: Dr. D.A.H. Jacobs, Central Electricity Research Labs.,  
Kelvin Avenue, Leatherhead, Surrey, England,  
Tele. 0372 374488.

- 1. Name of program or package:** D03EBF
- 2. Descriptive title:** Solver for Systems of Simultaneous Algebraic Equations
- 3. Problem domain:** Equations of five-point Molecule form on a two dimensional topologically rectangular mesh
- 4. Method of solution:** Strongly Implicit Procedure
- 5. Programming language:** FORTRAN
- 6. Precision:** Either
- 7. Portability:** Available on 48 machine ranges/compliers
- 8. Other packages required:** NAG
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 297      **Percentage comments:** 66%
- 12. Special features:**
- 13. Documentation and references:**  
**Detailed header comments?** Yes  
**User guide or manual, technical reports, papers, books:**  
NAG Library Manual  
NAG Library On-line Supplement
- 14. Approximate cost of obtaining software:** NAG Library costs \$1584/year
- 15. Restrictions on use:** License agreement
- 16. Distributor:** NAG (U.S.A.) Inc., 1250 Grace Court, Downers Grove, IL 60516  
Tel. 971-2337
- 17. Original source of software:**  
**Developer:** Dr. D. Jacobs  
**Institution:** C.E.G.B. (U.K.)  
**Sponsor:** NAG
- 18. For further information contact:**  
Mrs. Carolyn M. Smith  
NAG (U.S.A.) Inc.  
1250 Grace Court  
Downers Grove, IL 60516  
Tel. 971-2337  
Telex 23254708 (Teleserv DFLD)

1. **Name of program or package:** D03ECF
2. **Descriptive title:** Solver for Systems of Simultaneous Algebraic Equations
3. **Problem domain:** Equations of seven-point molecule form on a topologically rectangular mesh.
4. **Method of solution:** Strongly Implicit Procedure
5. **Programming language:** FORTRAN
6. **Precision:** Either
7. **Portability:** Available on 48 machine ranges/compliers
8. **Other packages required:** NAG
9. **Mode of use:** Callable subroutine
10. **Test or demonstration program available?** YES
11. **Length of code in lines:** 358      **Percentage comments:** 70%
12. **Special features:**
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - NAG Library Manual
    - NAG Library On-line Supplement
14. **Approximate cost of obtaining software:** NAG Library costs \$1584/year
15. **Restrictions on use:** License agreement
16. **Distributor:** NAG (U.S.A.) Inc.  
(see below)
17. **Original source of software:**
  - Developer:** Dr. D. Jacobs
  - Institution:** C.E.G.B.
  - Sponsor:** NAG
18. **For further information contact:**
  - Mrs. Carolyn M. Smith
  - NAG (U.S.A.) Inc.
  - 1250 Grace Court
  - Downers Grove, IL 60516
  - Tel. 971-2337
  - Telex 23254708 (Teleserv DFLD)

1. **Name of program or package:** D03UAF
2. **Descriptive title:** Performs one iteration of the Strongly Implicit Procedure.
3. **Problem domain:** Algebraic equations of five-point molecule form on a topologically rectangular mesh.
4. **Method of solution:** Strongly Implicit Procedure
5. **Programming language:** FORTRAN
6. **Precision:** Either
7. **Portability:** Available on 48 machine ranges/compiler
8. **Other packages required:** NAG
9. **Mode of use:** Callable Subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 375      **Percentage comments:** 66%
12. **Special features:**
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - NAG Library Manual
    - NAG On-line Supplement
14. **Approximate cost of obtaining software:** NAG Library costs \$1584/year
15. **Restrictions on use:** License agreement
16. **Distributor:** NAG (U.S.A.) Inc.  
(see below)
17. **Original source of software:**
  - Developer:** Dr. D. Jacobs
  - Institution:** C.E.G.B.
  - Sponsor:** NAG
18. **For further information contact:**
  - Mrs. Carolyn M. Smith
  - NAG (U.S.A.) Inc.
  - 1250 Grace Court
  - Downers Grove, IL 60516
  - Tel. 971-2337
  - Telex 23254708 (Teleserv DFLD)

1. **Name of program or package:** D03UBF
2. **Descriptive title:** Performs one iteration of the Strongly Implicit Procedure
3. **Problem domain:** Algebraic Equations of seven-point molecule form on a topologically rectangular mesh.
4. **Method of solution:** Strongly Implicit Procedure
5. **Programming language:** Fortran
6. **Precision:** Either
7. **Portability:** Available on 48 machine ranges/compilers
8. **Other packages required:** NAG
9. **Mode of use:** Callable subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 468                      **Percentage comments:** 50%
12. **Special features:**
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - NAG Library Manual
    - NAG On-line Supplement
14. **Approximate cost of obtaining software:** NAG Library costs \$1584/year
15. **Restrictions on use:** License agreement
16. **Distributor:** NAG (U.S.A.) Inc.
17. **Original source of software:**
  - Developer:** Dr. D. Jacobs
  - Institution:** C.E.G.B.
  - Sponsor:** NAG
18. **For further information contact:**
  - Mrs. Carolyn M. Smith
  - NAG (U.S.A.) Inc.
  - 1250 Grace Court
  - Downers Grove, IL 60516
  - Tel. 971-2337
  - Telex 23254708 (Teleserv DFLD)



1. **Name of program or package:** LLSS01
2. **Descriptive title:** Sparse linear least squares and linear system package
3. **Problem domain:** Linear least squares and unsymmetric linear systems
4. **Method of solution:** Orthogonalization
5. **Programming language:** IBM Fortran H
6. **Precision:** Mixed
7. **Portability:** Portable
8. **Other packages required:** None
9. **Mode of use:** Callable subroutines
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** about 1000      **Percentage comments:** 10%
12. **Special features:** None
13. **Documentation and references:**
  - Detailed header comments?** No
  - User guide or manual, technical reports, papers, books:**

Two technical reports at the Numerical Institute, Technical University of Denmark, Lyngby, Denmark;

Comp. & Maths. with Appls., 8(1982), pp. 119-135
14. **Approximate cost of obtaining software:** Free of charge
15. **Restrictions on use:** None
16. **Distributor:** Numerical Institute, Technical University of Denmark, Lyngby, Denmark
17. **Original source of software:**
  - Developer:** Z. Zlatev and H. B. Nielsen
  - Institution:** Numerical Institute, Technical University of Denmark
  - Sponsor:** The Danish Technical Science Research Council
18. **For further information contact:** H. B. Nielsen, Numerical Institute,

Technical University of Denmark

Lyngby, Denmark

1. **Name of program or package:** SPARSPAK - B
2. **Descriptive title:** Sparse matrix package
3. **Problem domain:** General square systems of linear equations, least squares problems, underdetermined systems of linear equations.
4. **Method of solution:** Orthogonal decomposition
5. **Programming language:** FORTRAN
6. **Precision:** Either single or double
7. **Portability:** Developed on IBM4341 using ANSI FORTRAN.
8. **Other packages required:** SPARSPAK
9. **Mode of use:** Callable subroutines
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 9000      **Percentage comments:** about 10%
12. **Special features:** Require use of secondary storage
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:** User guide is available
14. **Approximate cost of obtaining software:** \$100.00 distribution fee
15. **Restrictions on use:** none
16. **Distributor:** Waterloo Research Institute  
Needles Hall  
University of Waterloo, Waterloo, Ontario, CANADA, N2L 3G1.
17. **Original source of software:**
  - Developer:** Alan George, Michael Heath, Esmond Ng
  - Institution:** University of Waterloo
  - Sponsor:** Natural Sciences and Engineering Research Council of Canada and U.S. Department of Energy
18. **For further information contact:**
  - Dr. Alan George
  - Department of Computer Science
  - University of Waterloo
  - Waterloo, Ontario
  - CANADA N2L 3G1
  - Phone: (519) 885-1211, ext.3473

**1. Name of program or package:** LASSO

**2. Descriptive title:** Least square Adjustments for Sparse Systems, Out-of-core with optional inverse elements.

**3. Problem domain:** Symmetric positive definite linear systems with reordering of equations to minimize storage. Primarily least square adjustments.

**4. Method of solution:** Minimum column profile reordering and Cholesky factorization.

**5. Programming language:** FORTRAN (compatible with FORTRAN 77)

**6. Precision:** Double precision.

**7. Portability:** Operational on Univac 1100, IBM 360/195, IBM 3300. Portability depends on FORTRAN 77, and logical functions for AND, OR, and LOCF the memory location of an array.

**8. Other packages required:** Optional interface for SPARSPAK, but not required

**9. Mode of use:** Subroutine calls.

**10. Test or demonstration program available?** Yes

**11. Length of code in lines:** 7000                      **Percentage comments:** 5-10%

**12. Special features:** Input is usually observation equations and output is solution vector and optional partial matrix inverse (ie. elements inside sparse storage).

Optional assembly code for disk I/O on Univac 1100 and IBM 360.

**13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:** "Subroutine Package for Processing Large Sparse Least-Squares Problems", William H Dillinger, NOAA Technical Memorandum, NOS, NGS-29, January 1981.

**14. Approximate cost of obtaining software:** \$45

**15. Restrictions on use:** None

**16. Distributor:** NOAA/NOS/NGS, National Geodetic Information Center, OA/C184  
6001 Executive Blvd.  
Rockville, MD 20852                      Phone (301) 443-8623

**17. Original source of software:**

**Developer:** W. H. Dillinger, R. H. Hanson

**Institution:** NOAA, NOS, National Geodetic Survey

**Sponsor:** U.S. Department of Commerce, NOAA, NOS, NGS

**18. For further information contact:** W. H. Dillinger  
NOAA, NOS, National Geodetic Survey  
6001 Executive Blvd.  
Rockville, MD 20852  
Phone (301) 443-2520

- 1. Name of program or package:** LSQR
- 2. Descriptive title:** Sparse linear system solver  
Sparse linear least squares solver
- 3. Problem domain:** Unsymmetric linear systems  
Overdetermined systems
- 4. Method of solution:** Damped least squares  
Lanczos bidiagonalization
- 5. Programming language:** ANSI FORTRAN
- 6. Precision:** Single, easily converted to double
- 7. Portability:** Developed on IBM and Burroughs;  
easily portable to other machines
- 8. Other packages required:** BLAS
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 574                      **Percentage comments:** 66%
- 12. Special features:** BLAS operations are efficient in a paging environment and on pipeline machines.  
Overall efficiency may depend on user's own routine for computing  $y + Ax$  and  $x + A^T y$ .
- 13. Documentation and references:**  
**Detailed header comments?** Yes  
**User guide or manual, technical reports, papers, books:**  
Papers: C.C. Paige and M.A. Saunders, "LSQR: An algorithm for sparse linear equations and sparse least squares", ACM TOMS 8, 1 (1982) 43-71.  
C.C. Paige and M.A. Saunders, "Algorithm 583. LSQR: Sparse linear equations and least squares problems", ACM TOMS 8, 2 (1982).
- 14. Approximate cost of obtaining software:** See ACM Algorithms Order Form in ACM TOMS.
- 15. Restrictions on use:** None
- 16. Distributor:** ACM Algorithms Distribution Service  
IMSL, Inc.  
Sixth Floor, NBC Building, 7500 Bellaire Blvd.  
Houston, TX 77036
- 17. Original source of software:**  
**Developer:** Chris Paige                      Michael Saunders  
**Institution:** McGill University                      Stanford University  
**Sponsor:** Natural Sciences and Engineering Research Council of Canada;  
DSIR, New Zealand; DOE, NSF, ONR.
- 18. For further information contact:**  
Michael Saunders  
Department of Operations Research  
Stanford University  
Stanford, CA 94305                      Ph: (415)497-1875

**1. Name of program or package:** RNCLIN

**2. Descriptive title:** "Sparse Linear Systems and Least Squares Solver"

**3. Problem domain:** Real Systems of Linear Equations or Least Squares Problems  
using  $l_2$  norm. No restriction on coefficient matrix.

**4. Method of solution:** Accelerated Iterative Column Projection Methods.

**5. Programming language:** Fortran IV

**6. Precision:** Either

**7. Portability:** Developed using IBM 360/370 computer. Is portable or easily modified  
for other machines.

**8. Other packages required:** Program to generate matrix equation or Least Squares Prob.

**9. Mode of use:** Callable Subroutine.

**10. Test or demonstration program available?** Yes.

**11. Length of code in lines:** 343 lines      **Percentage comments:** 67 %

**12. Special features:** Uses column packed storage for matrices - can be modified to  
use secondary storage or generate columns as necessary (Would involve  
additional programming by user).

**13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:**

User's Guide.

Technical reports and papers as soon as published.

**14. Approximate cost of obtaining software:** To be determined based on cost.

**15. Restrictions on use:** Propriety.

**16. Distributor:** Dr. Larry F. Bennett  
Department of Mathematics, South Dakota State University  
Brookings, South Dakota 57007 (Phone: 1-605-688-6218)

**17. Original source of software:**

**Developer:** Dr. Larry F. Bennett

**Institution:** South Dakota State University

**Sponsor:** South Dakota State University

**18. For further information contact:**

Dr. Larry F. Bennett

Department of Mathematics

South Dakota State University

Brookings, South Dakota 57007

Office Phone: 1-605-688-6218      Home Phone: 1-605-692-2161

1. **Name of program or package:** RNRWIN
2. **Descriptive title:** "Sparse Linear System and Least Squares Solver"
3. **Problem domain:** Real Systems of Linear Equations or Least Squares Problems using  $l_2$  norm. No restriction on coefficient matrix.
4. **Method of solution:** Accelerated Iterative Row Projection Methods.
5. **Programming language:** Fortran IV
6. **Precision:** Either
7. **Portability:** Developed using IBM 360/370. Is portable or easily modified for other machines.
8. **Other packages required:** Program to generate matrix equation or Least Squares Prob.
9. **Mode of use:** Callable Subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 325 lines      **Percentage comments:** 71 %
12. **Special features:** Uses row-packed storage for matrices - can be modified to use secondary storage or generate rows as needed (Would involve additional programming by user).
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - User's Guide
    - Technical reports and papers as soon as published.
14. **Approximate cost of obtaining software:** To be determined based on cost.
15. **Restrictions on use:** Propriety
16. **Distributor:** Dr. Larry F. Bennett  
Department of Mathematics, South Dakota State University  
Brookings, South Dakota 57007 (Phone: 1-605-688-6218)
17. **Original source of software:**
  - Developer:** Dr. Larry F. Bennett
  - Institution:** South Dakota State University
  - Sponsor:** South Dakota State University
18. **For further information contact:**
  - Dr. Larry F. Bennett
  - Department of Mathematics
  - South Dakota State University
  - Brookings, South Dakota 57007
  - Office Phone: 1-605-688-6218      Home Phone: 1-605-692-2161

**1. Name of program or package:** EISPACK

**2. Descriptive title:** A Package of Matrix Eigensystem Routines

**3. Problem domain:** Standard eigensystem problem (real and complex),  
generalized eigensystem problem (real), singular value decomposition

**4. Method of solution:** QR, LR, QL, rational QR, bisection, QZ, inverse  
iteration

**5. Programming language:** FORTRAN

**6. Precision:** Double on IBM 360, single on others

**7. Portability:** Specific version for each of several machines

**8. Other packages required:** None

**9. Mode of use:** Library of callable subroutines

**10. Test or demonstration program available?** Yes

**11. Length of code in lines:** 10,000      **Percentage comments:** 50%

**12. Special features:** None

**13. Documentation and references:** Machine-readable document for each subroutine  
**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:**

B. T. Smith et al., Matrix Eigensystem Routines - EISPACK Guide, Springer-Verlag, Lecture Notes in Computer Science, Vol. 6 (2nd ed.), 1976

B. S. Garbow et al., Matrix Eigensystem Routines - EISPACK Guide Extension  
Springer-Verlag, Lecture Notes in Computer Science, Vol. 51, 1977

**14. Approximate cost of obtaining software:** \$75

**15. Restrictions on use:** None

**16. Distributor:** NESC, Argonne National Laboratory (312) 972-7250  
IMSL, Houston, Texas (713) 772-1927

**17. Original source of software:** Handbook of Linear Algebra, Wilkinson & Reinsch (eds.)

**Developer:** Applied Mathematics Division

**Institution:** Argonne National Laboratory

**Sponsor:** NSF, DOE

**18. For further information contact:**

Burton S. Garbow  
Mathematics and Computer Science Division  
Argonne National Laboratory  
9700 S. Cass Avenue  
Argonne, Illinois 60439  
Phone: (312) 972-7184

1. **Name of program or package:** BES
2. **Descriptive title:** Basic Eigenanalysis System - Symmetric
3. **Problem domain:** Large, sparse, generalized, symmetric, real
4. **Method of solution:** Block Lanczos with shifting
5. **Programming language:** FORTRAN 77
6. **Precision:** Single or double
7. **Portability:** Good
8. **Other packages required:** VMSYST, EZ-GAL (data management)
9. **Mode of use:** Independent program system, interactive
10. **Test or demonstration program available?** Included
11. **Length of code in lines:**  $\approx$  100,000      **Percentage comments:** 40%
12. **Special features:** Problem oriented language, interactive problem description followed by batch analysis, spectral range (section) specification of desired eigenpairs
13. **Documentation and references:**
  - Detailed header comments?** Moderate
  - User guide or manual, technical reports, papers, books:**  
"Basic Eigenanalysis System" (in preparation)
14. **Approximate cost of obtaining software:** Not yet available
15. **Restrictions on use:**
16. **Distributor:**
17. **Original source of software:**
  - Developer:** Paul S. Jensen
  - Institution:** Lockheed Missiles and Space Co.
  - Sponsor:** Lockheed Missiles and Space Co.
18. **For further information contact:**
  - Paul S. Jensen
  - Lockheed Research Laboratory 5233/255
  - 3251 Hanover St.
  - Palo Alto, CA 94304



- 1. Name of program or package:** BLMAIN
- 2. Descriptive title:** Eigenvalue/Eigenvector Computations
- 3. Problem domain:** Large Symmetric Matrices
- 4. Method of solution:** Block Lanczos Recursion with Limited Reorthogonalization
- 5. Programming language:** FORTRAN
- 6. Precision:** Double
- 7. Portability:** IBM/168/3033
- 8. Other packages required:** Eispack
- 9. Mode of use:** Stand-alone (can easily be modified to callable subroutines)
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** ~1000      **Percentage comments:** ~55%
- 12. Special features:** None
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - Book: Lanczos Algorithms for Large Symmetric Eigenvalue Computations by Jane Cullum and Ralph Willoughby.  
Volume? in Progress in Scientific Computing Series ed.  
G. Golub, H. Kreiss, S. Arbarbanel, R. Glowinski,  
Birkhäuser Boston Inc. 1983
- 14. Approximate cost of obtaining software:** Please contact authors
- 15. Restrictions on use:** None
- 16. Distributor:** Please contact authors
- 17. Original source of software:**
  - Developer:** Jane Cullum and Ralph A. Willoughby
  - Institution:** IBM T.J. Watson Research Laboratory, Yorktown Heights, N.Y. 10598
  - Sponsor:**
- 18. For further information contact:**
  - Jane Cullum
  - IBM T.J. Watson Research Center
  - Yorktown Heights, N. Y. 10598
  - 914-945-2227 (if no answer message may be left with dept. secretary at 914-945-2331)

1. **Name of program or package:** LMAIN & LVMAIN
2. **Descriptive title:** Eigenvalue/Eigenvector Computations
3. **Problem domain:** Large Symmetric Matrices
4. **Method of solution:** Lanczos method with no reorthogonalization
5. **Programming language:** FORTRAN
6. **Precision:** Double
7. **Portability:** IBM/168/3033
8. **Other packages required:** None (Needs Random Number Generator)
9. **Mode of use:** Stand-alone (can easily be modified to callable subroutines)
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** ~2100                      **Percentage comments:** ~55%
12. **Special features:** None
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - Book:** Lanczos Algorithms for Large Symmetric Eigenvalue Computations by Jane Cullum and Ralph Willoughby.  
Volume? in Progress in Scientific Computing Series ed.  
G. Golub, H. Kreiss, S. Arbarbanel, R. Glowinski,  
Birkhäuser Boston Inc. 1983.
14. **Approximate cost of obtaining software:** Please contact authors
15. **Restrictions on use:** None
16. **Distributor:** Please contact authors
17. **Original source of software:**
  - Developer:** Jane Cullum and Ralph A. Willoughby
  - Institution:** IBM T.J. Watson Research Laboratory, Yorktown Heights, N. Y. 10598
  - Sponsor:**
18. **For further information contact:**
  - Jane Cullum
  - IBM T.J. Watson Research Center
  - Yorktown Heights, N. Y. 10598
  - 914-945-2227 (if no answer message may be left with dept. secretary at 914-945-2331)

- 1. Name of program or package:** EA12
- 2. Descriptive title:** Find a group of eigenvalues and vectors.
- 3. Problem domain:** Sparse symmetric matrices.
- 4. Method of solution:** Simultaneous iteration.
- 5. Programming language:** Fortran 66.
- 6. Precision:** Both single and double precision versions are available.
- 7. Portability:** Fortran 66.
- 8. Other packages required:** Harwell subroutines EA13, FA01, FM01, FM02.
- 9. Mode of use:** Subroutine calls.
- 10. Test of demonstration program available:** Yes.
- 11. Length of code in lines:** 427 **Percentage comments:** 37%  
(934 with dependencies)
- 12. Special features:** Reverse communication makes its use particularly flexible.
- 13. Documentation and references:**  
**Detailed header comments?** No.  
**User guide or manual, technical reports, papers, books:**  
Harwell Subroutine Library Specification Document.  
The code is based on a adaptation by J.K.Reid of the work of H.Rutishauser (1970)  
Simultaneous iteration methods for symmetric matrices. Numer. Math., **16**, 205-223.
- 14. Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
- 15. Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
- 16. Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell,  
Oxfordshire OX11 0RA, England.
- 17. Original source of software:**  
**Developer:** I.S.Duff.  
**Institution:** A.E.R.E. Harwell.  
**Sponsor:** A.E.R.E. Harwell.
- 18. For further information contact:** I.S.Duff or J.K.Reid.

1. **Name of program or package:** EA14
2. **Descriptive title:** Eigenvalue spectrum.
3. **Problem domain:** Sparse symmetric matrices.
4. **Method of solution:** Lanczos algorithm.
5. **Programming language:** Fortran 66.
6. **Precision:** Double precision.
7. **Portability:** Fortran 66.
8. **Other packages required:** Harwell subroutine FA01.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 648 **Percentage comments:** 29%  
(756 with dependencies)
12. **Special features:** Automatically chooses the number of Lanczos steps necessary to have confidence that the spectrum in a given interval has been found.
13. **Documentation and references:**
  - Detailed header comments?** Yes, for auxiliary routines.
  - User guide or manual, technical reports, papers, books:**
    - Harwell Subroutine Library Specification Document.
    - B.N.Parlett and J.K.Reid (1981), Tracking the progress of Lanczos' algorithm for the very large symmetric eigenproblem. I.M.A. J. Num. Anal., 1, 135-155.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (i), (ii), (iii), (iv) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell,  
Oxfordshire OX11 0RA, England.
17. **Original source of software:**
  - Developer:** J.K.Reid.
  - Institution:** A.E.R.E. Harwell.
  - Sponsor:** A.E.R.E. Harwell.
18. **For further information contact:** The developer.

1. **Name of program or package:** LAS02
2. **Descriptive title:** Eigenvalue Solver
3. **Problem domain:** Sparse Symmetric Eigenvalue Problems
4. **Method of solution:** The Lanczos Algorithm with Selective Orthogonalization
5. **Programming language:** ANSI FORTRAN 66
6. **Precision:** Either
7. **Portability:** Completely Portable
8. **Other packages required:** None
9. **Mode of use:** Callable Subroutines
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 3288      **Percentage comments:** 45%  
each precision
12. **Special features:** Requires user supplied subroutines for matrix  
vector multiplication and temporary storage of the  
Lanczos vectors
13. **Documentation and references:**
  - Detailed header comments?** yes
  - User guide or manual, technical reports, papers, books:**
    - Scott, D. S., "Block Lanczos Software for Symmetric Eigenvalue Problems,"  
Computer Sciences Division, Union Carbide Corporation, Nuclear Div.,  
November 1979, ORNL/CSD-48
    - LAS02.DOC, a text file available with the package
14. **Approximate cost of obtaining software:** Tape fee from NESC  
Free from Author over ARPA net
15. **Restrictions on use:** None
16. **Distributor:** National Energy Software Center, Argonne National Lab  
CS.SCOTT@UTEXAS-20 on the ARPA net
17. **Original source of software:**
  - Developer:** D. S. Scott
  - Institution:** Oak Ridge National Lab
  - Sponsor:** DOE
18. **For further information contact:**
  - David S. Scott
  - Computer Sciences Dept.
  - PAI 3.28
  - University of Texas at Austin
  - Austin, TX 78712

1. **Name of program or package:** STLM
2. **Descriptive title:** Sparse eigenvalue problem solver
3. **Problem domain:** Large, sparse, generalized, symmetric, and real eigenvalue problems
4. **Method of solution:** The Lanczos method applied on a sequence of shifted and inverted problems
5. **Programming language:** ANSI FORTRAN. (will also run as a FORTRAN 77 package).
6. **Precision:** Either (type converter available).
7. **Portability:** CDC Cyber 730, PRIME 550-II. Easily portable (has passed the PFORT Verifier).
8. **Other packages required:** Includes all necessary code, but linear system solver part may be replaced by the user's own if it makes use of special algorithms or data structures.
9. **Mode of use:** Callable subroutine.
10. **Test or demonstration program available?** Yes.
11. **Length of code in lines:** 6500                      **Percentage comments:** 46
12. **Special features:** Requires a direct access file or virtual memory for large problems.
13. **Documentation and references:**
  - Detailed header comments?** No
  - User guide or manual, technical reports, papers, books:** User guide and The Spectral Transformation Lanczos Method for the Numerical Solution of Large Sparse Generalized Symmetric Eigenvalue Problems, Math. of Comp., vol 35, no. 152, 1251-1268.
14. **Approximate cost of obtaining software:**
15. **Restrictions on use:** Will try to get it published in ACM TOMS.
16. **Distributor:**
17. **Original source of software:**
  - Developer:** Thomas Ericsson and Axel Ruhe
  - Institution:** University of Umeå, Inst of Information Processing
  - Sponsor:** The Swedish Institute of Applied Mathematics (partly)
18. **For further information contact:**
  - Thomas Ericsson
  - University of Umeå
  - Institute of Information Processing
  - S-901 87 Umeå
  - Sweden

- 1. Name of program or package:** Subroutine TRACMN
- 2. Descriptive title:** Generalized Eigenvalue Routine Using Trace Minimization and Shifting
- 3. Problem domain:** Generalized eigenvalues, real, symmetric, only matrix-vector multiply required
- 4. Method of solution:** Trace minimization
- 5. Programming language:** FLECS (FORTRAN)
- 6. Precision:** Single
- 7. Portability:** 66 Standard
- 8. Other packages required:** BLAS, LINPACK, EISPACK, URAND (Forsythe Malcom & Moler)
- 9. Mode of use:** Subroutine call
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 586 **Percentage comments:** 30%
- 12. Special features:**
- 13. Documentation and references:**  
**Detailed header comments?** Yes  
**User guide or manual, technical reports, papers, books:**  
University of Illinois Report UIUCDCS-R-81-1056 Feb. 1981  
SIAM J. Num. Analysis, Dec. 1982.
- 14. Approximate cost of obtaining software:** None
- 15. Restrictions on use:** None
- 16. Distributor:** Authors
- 17. Original source of software:**  
**Developer:** John A. Wisniewski  
**Institution:** University of Illinois  
**Sponsor:** NSF
- 18. For further information contact:**
- |                              |    |                           |
|------------------------------|----|---------------------------|
| John A. Wisniewski           |    | Ahmed H. Sameh            |
| Division 2113                |    | Dept. of Computer Science |
| Sandia National Laboratories | or | University of Illinois    |
| Albuquerque, NM 87185        |    | 1304 W. Springfield       |
|                              |    | Urbana, IL 61801          |

**1. Name of program or package:** SIMITZ

**2. Descriptive title:** Eigenvectors and eigenvalues of real generalized symmetric matrices by simultaneous iteration.

**3. Problem domain:** Structural analysis, numerical weather prediction.

**4. Method of solution:** Subspace iteration (Rutishauser-Reinsch algorithm)

**5. Programming language:** Version 1 - FORTRAN 66  
Version 2 - FORTRAN 78

**6. Precision:** Single (Easily converted to double)

**7. Portability:** Control Data Corporation Cyber, fully portable.

**8. Other packages required:** Version 1 - EISPACK, Version 2 - SLATEC

**9. Mode of use:** Callable subroutine.

**10. Test or demonstration program available?** Yes

**11. Length of code in lines:** 550                      **Percentage comments:** 40%

**12. Special features:** Program is easily adaptable to vector or array processors.

**13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:**

Paul J. Nikolai, ALGORITHM 538 - Eigenvectors and eigenvalues of real generalized symmetric matrices by simultaneous iteration, ACM Trans. Math. Software 5 (1979), 118-125.

**14. Approximate cost of obtaining software:** Version I - Current IMSL fees.  
Version II - None

**15. Restrictions on use:** None

**16. Distributor:** Version I - IMSL                      Version II - Paul J. Nikolai  
7500 Bellaire Blvd                      AFWAL/FIBR  
Houston, TX 77036                      Wright-Patterson AFB OH  
(713) 772-1927                      (513) 255-5350                      45433

**17. Original source of software:**

**Developer:** Paul J. Nikolai

**Institution:** US Air Force Wright Aeronautical Laboratories

**Sponsor:** Air Force Systems Command

**18. For further information contact:**

Paul J. Nikolai

AFWAL/FIBR

Wright-Patterson AFB, OH 45433

(513) 255-5350

Autovon 785-5350



1. **Name of program or package:** LA05
2. **Descriptive title:** Solves linear sets of equations.
3. **Problem domain:** Linear programming bases.
4. **Method of solution:** Sparse Bartels-Golub algorithm.
5. **Programming language:** IBM Fortran.
6. **Precision:** Both single and double precision versions are available.
7. **Portability:** Fortran 66 version available.
8. **Other packages required:** Harwell subroutine MC20.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 959      **Percentage comments:** 22%  
(1062 with dependencies)
12. **Special features:** Markowitz' pivoting used for original factorization. If updating can be performed by permutations alone, without fill-in, then this is done.
13. **Documentation and references:**  
**Detailed header comments?** No.  
**User guide or manual, technical reports, papers, books:**  
Harwell Subroutine Library Specification Document.  
J.K.Reid (1976), Fortran subroutines for handling sparse linear programming bases, Harwell report R.8269, H.M.S.O., London.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell',  
Oxfordshire OX11 0RA, England.
17. **Original source of software:**  
**Developer:** J.K.Reid.  
**Institution:** A.E.R.E. Harwell.  
**Sponsor:** A.E.R.E. Harwell.
18. **For further information contact:** The developer.

- 1. Name of program or package:** SPLP
- 2. Descriptive title:** Sparse linear programming subprogram
- 3. Problem domain:** Linear optimization problems with general bounds on the variables (including no bounds) and linear constraints.
- 4. Method of solution:** Basicly the Revised Simplex method.
- 5. Programming language:** SFTRAN and FORTRAN 77
- 6. Precision:** Single
- 7. Portability:** Developed and used on CDC, usea on VAX and IBM.
- 8. Other packages required:** BLAS, XERROR (SLATEC library error package)  
(copies in package)
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** code 5600 (FORTRAN) **Percentage comments:** 10% comments  
document 1500
- 12. Special features:** Permits out-of-core storage of data matrix (may require machine dependent I/O subprograms -- 3 types now provided) efficient design for paging, written in several subprograms so easily segmented.
- 13. Documentation and references:** Yes.  
**Detailed header comments?** Brief document and full.  
**User guide or manual, technical reports, papers, books:**  
"A Sparse Linear Programming Subprogram," R. J. Hanson, K. L. Hiebert,  
Sandia Technical Report SAND81-0297, Sandia National Labs, Albuquerque, NM 87185.
- 14. Approximate cost of obtaining software:** Send tape with letter of request.
- 15. Restrictions on use:** Rights to redistribute (modified) LA05 within the package have been purchased.
- 16. Distributor:** Ultimately NESC
- 17. Original source of software:**  
**Developer:** R. J. Hanson, K. L. Hiebert  
**Institution:** Sandia National Labs  
**Sponsor:** DOE
- 18. For further information contact:**

Dick Hanson. Org. 5642 Sandia National Labs. Albuquerque, NM 87185 (505) 844-1715 FTS 844-1715	Kathie Hiebert Org. 5642 Sandia National Labs. Albuquerque, NM 87185 (505) 844-3538 FTS 844-3538
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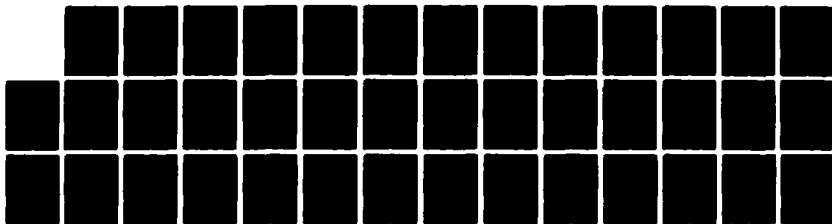
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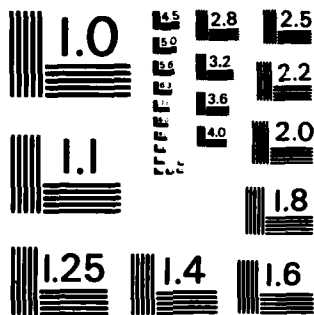


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1. **Name of program or package:** XMP
2. **Descriptive title:** Hierarchically structured linear programming library
3. **Problem domain:** Linear Programming
4. **Method of solution:** Simplex Method
5. **Programming language:** FORTRAN
6. **Precision:** Double (or single for Control Data)
7. **Portability:** Any FORTRAN compiler-highly portable
8. **Other packages required:** LAØ5 package from Harwell
9. **Mode of use:** Subroutine Library
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 20,000      **Percentage comments:** 50%
12. **Special features:** primal and dual simplex methods;  
simple and generalized upper bounds;  
postoptimality analysis
13. **Documentation and references:**  
    **Detailed header comments?** Yes  
    **User guide or manual, technical reports, papers, books:**  
    "The Design of the XMP Library", Transactions on Mathematical Software,  
    Vol. 7, No. 4, December, 1981.
14. **Approximate cost of obtaining software:** negotiable
15. **Restrictions on use:** negotiable
16. **Distributor:** Management Information Systems Dept.  
University of Arizona
17. **Original source of software:**  
    **Developer:** Roy Marsten  
    **Institution:** NBER/MIT/University of Arizona  
    **Sponsor:** NSF
18. **For further information contact:**  
    Professor Roy Marsten  
    Management Information Systems Dept.  
    University of Arizona  
    Tucson, Arizona - 85721

**1. Name of program or package:** SIMPLE

**2. Descriptive title:** Sparse linear programming problem solver

**3. Problem domain:** Linear programming

**4. Method of solution:** Revised simplex

**5. Programming language:** AP FORTRAN and FPS-164 assembly language

**6. Precision:** 64-bit word

**7. Portability:** Developed for the FPS-164 Array Processor.

**8. Other packages required:** FPS-164 Math Library (APMATH64)

**9. Mode of use:** Callable subroutine

**10. Test or demonstration program available?** No

**11. Length of code in lines:** 558

**Percentage comments:** 63

**12. Special features:** Takes advantage of the parallel, pipelined architecture of the FPS-164 array processor.

**13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:**

APMATH64 Reference Manual

Floating Point Systems, Inc.

**14. Approximate cost of obtaining software:** This routine is included in the FPS-164 Math Library (APMATH64)

**15. Restrictions on use:** License agreement required

**16. Distributor:** Floating Point Systems, Inc.

P.O. Box 23489

Portland, OR 97223

(503) 641-3151

**17. Original source of software:**

**Developer:** Ron Coleman

**Institution:** Floating Point Systems, Inc.

**Sponsor:** Floating Point Systems, Inc.

**18. For further information contact:**

Phil Vaughn

Floating Point Systems, Inc.

P.O. Box 23489

Portland, OR 97223

(503) 641-3151 TLX: 360470 FLOATPOIN BEAV

1. **Name of program or package:** P3, P4
2. **Descriptive title:** Subroutines for Hellerman-Rarick  $P^3$  and  $P^4$  algorithms
3. **Problem domain:** Useful in codes for linear programming and solving sparse nonlinear equations via tearing.
4. **Method of solution:** "Symbolic" computation on arrays of integers.
5. **Programming language:** IBM Fortran with simple conversion to ANSI Fortran.
6. **Precision:** Single or double -- no floating-point data are used.
7. **Portability:** Developed on IBM 370/168; acceptable to PFORT Verifier (after simple conversion)
8. **Other packages required:** Harwell Library subroutines MC13D, MC21A
9. **Mode of use:** Subroutine call; P4 calls P3.
10. **Test or demonstration program available?** No.
11. **Length of code in lines:** 684                      **Percentage comments:** 45.8%
12. **Special features:** Some integer arrays can be "short" integers -- INTEGER\*2 in IBM Fortran. Changing "INTEGER\*2" to "INTEGER" is the simple conversion mentioned above.
13. **Documentation and references:**
  - Detailed header comments?** Yes.
  - User guide or manual, technical reports, papers, books:** references:
    - E. Hellerman and D.C. Rarick, "The Partitioned Preassigned Pivot Procedure ( $P^4$ )", pp. 67-76 of Sparse Matrices and Their Applications, edited by D.J. Rose and R.A. Willoughby, Plenum Press, New York, 1972.
    - E. Hellerman and D.C. Rarick, "Reinversion with the Preassigned Pivot Procedure", Math. Programming 1 (1971), pp. 195-216.
14. **Approximate cost of obtaining software:** no fee
15. **Restrictions on use:** none
16. **Distributor:** see item 18.
17. **Original source of software:**
  - Developer:** David M. Gay
  - Institution:** Center for Computational Research in Economics and Management Science,
  - Sponsor:** NSF                      Massachusetts Institute of Technology.
18. **For further information contact:** David M. Gay
  - Bell Labs
  - 600 Mountain Avenue
  - Murray Hill, NJ 07974
  - phone: (201) 582-5623

- 1. Name of program or package:** MINOS - HP
- 2. Descriptive title:** Linear Programming Package for HP1000
- 3. Problem domain:** Linear Programming
- 4. Method of solution:** Simplex method
- 5. Programming language:** FORTRAN
- 6. Precision:** Single
- 7. Portability:** HP1000F; portable (see 12 below)
- 8. Other packages required:**
- 9. Mode of use:** Stand-alone
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 6700 **Percentage comments:** 5%
- 12. Special features:** Stores large array, Z(25000), in (paged) memory;  
some machine-dependent routines
- 13. Documentation and references:**  
**Detailed header comments?** No  
**User guide or manual, technical reports, papers, books:** MINOS User Guide  
MINOS System Manual
- 14. Approximate cost of obtaining software:** TBA
- 15. Restrictions on use:** TBA
- 16. Distributor:** TBA
- 17. Original source of software:**  
**Developer:** Michael Saunders, Systems Optimization Laboratory  
**Institution:** Stanford University  
**Sponsor:** U.S. and New Zealand governments
- 18. For further information contact:** James E. Giles  
Tennessee Valley Authority  
P.O. Drawer E  
Norris, Tennessee 37828  
(FTS) 856-4460



- 1. Name of program or package:** NS03
- 2. Descriptive title:** Solves non-linear sets of equations.
- 3. Problem domain:** Equations with sparse Jacobian matrices.
- 4. Method of solution:** Marquardt's algorithm.
- 5. Programming language:** IBM Fortran.
- 6. Precision:** Both single and double precision versions are available.
- 7. Portability:** Fortran 66 version available.
- 8. Other packages required:** Harwell subroutines MA17, FM01, MC09, TD02.
- 9. Mode of use:** Subroutine calls.
- 10. Test of demonstration program available:** Yes.
- 11. Length of code in lines:** 668 **Percentage comments:** 24%  
(1034 with dependencies)
- 12. Special features:** Provision of derivatives is optional.
- 13. Documentation and references:**  
**Detailed header comments?** No.  
**User guide or manual, technical reports, papers, books:**  
 Harwell Subroutine Library Specification Document.  
 J.K.Reid (1972) Fortran subroutines for the solution of sparse systems of non-linear equations. Harwell report R-7293, H.M.S.O., London.
- 14. Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
- 15. Restrictions on use:** (ii) and (iii) (see appendix on Harwell Subroutine Library).
- 16. Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell,  
Oxfordshire OX11 0RA, England.
- 17. Original source of software:**  
**Developer:** J.K.Reid.  
**Institution:** A.E.R.E. Harwell.  
**Sponsor:** A.E.R.E. Harwell.
- 18. For further information contact:** The developer.

1. **Name of program or package:** VA08
2. **Descriptive title:** Function minimization.
3. **Problem domain:** Functions with sparse Hessian matrices.
4. **Method of solution:** Conjugate gradients.
5. **Programming language:** Fortran 66.
6. **Precision:** Both single and double precision versions are available.
7. **Portability:** Fortran 66
8. **Other packages required:** Harwell subroutine FM02.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 86 **Percentage comments:** 1%  
(211 with dependencies)
12. **Special features:**
13. **Documentation and references:**  
Detailed header comments? No.  
**User guide or manual, technical reports, papers, books:**  
Harwell Subroutine Library Specification Document.  
R.Fletcher and C.M.Reeves (1964) Function minimization by conjugate gradients. Comp. J. 7,  
149-154.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell,  
Oxfordshire OX11 0RA, England.
17. **Original source of software:**  
**Developer:** R.Fletcher.  
**Institution:** Univ. of Dundee.  
**Sponsor:** A.E.R.E. Harwell.
18. **For further information contact:** The developer.

1. **Name of program or package:** VA14
2. **Descriptive title:** Function minimization.
3. **Problem domain:** Functions with sparse Hessian matrices.
4. **Method of solution:** Conjugate gradients.
5. **Programming language:** Fortran 66.
6. **Precision:** Both single and double precision versions are available.
7. **Portability:** Fortran 66.
8. **Other packages required:** None.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 191 **Percentage comments:** 13%
12. **Special features:** Automatic restart procedure included.
13. **Documentation and references:**  
**Detailed header comments?** No.  
**User guide or manual, technical reports, papers, books:**  
Harwell Subroutine Library Specification Document.  
M.J.D.Powell (1977) Restart procedures for the conjugate gradient method. Math. Prog. 12, 241-254.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell, Oxfordshire OX11 0RA, England.
17. **Original source of software:**  
**Developer:** M.J.D.Powell.  
**Institution:** Univ. of Cambridge.  
**Sponsor:** A.E.R.E. Harwell.
18. **For further information contact:** The developer.

1. **Name of program or package:** VE05
2. **Descriptive title:** Minimization subject to linear constraints.
3. **Problem domain:** Sparse constraint matrix.
4. **Method of solution:** Variable metric algorithm.
5. **Programming language:** IBM Fortran.
6. **Precision:** Both single and double precision versions are available.
7. **Portability:** Fortran 66 version available.
8. **Other packages required:** Other Harwell subroutines.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 1075                      **Percentage comments:** 16%  
(3022 with dependencies)
12. **Special features:** Essentially extends sparse linear programming techniques to non-linear objective functions.
13. **Documentation and references:**  
    **Detailed header comments?** No.  
    **User guide or manual, technical reports, papers, books:**  
        Harwell Subroutine Library Specification Document.  
        A.Buckley (1975) An alternate implementation of Goldfarb's minimization algorithm. Math. Prog. 8, 207-231.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell, Oxfordshire OX11 0RA, England.
17. **Original source of software:**  
    **Developer:** A.Buckley.  
    **Institution:** Concordia Univ., Montreal.  
    **Sponsor:** A.E.R.E. Harwell.
18. **For further information contact:** The developer.

- 1. Name of program or package:** MINOS
- 2. Descriptive title:** Sparse nonlinear programming system
- 3. Problem domain:** Optimization involving a nonlinear objective function, bounds, and linear and nonlinear constraints.
- 4. Method of solution:** Simplex method for linear programs; reduced-gradient method + quasi-Newton for linear constraints; projected Lagrangian method for nonlinear constraints.
- 5. Programming language:** FORTRAN IV
- 6. Precision:** Single or mixed, depending on machine.
- 7. Portability:** Developed on IBM; easily portable to other (large) machines.
- 8. Other packages required:** None
- 9. Mode of use:** Stand-alone, primarily; callable by expert user.
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 10,000      **Percentage comments:** 35%
- 12. Special features:** In-core solution procedure; designed for efficiency in a paging environment; disk files used to input data and save current solution.
- 13. Documentation and references:**  
**Detailed header comments?** No  
**User guide or manual, technical reports, papers, books:**  
     User manuals: reports SOL 77-9, 77-31, 80-14, 80-15, 80-100,  
                     Department of Operations Research, Stanford University.  
     Papers:       Mathematical Programming 14 (1978) 41-72.  
                     Mathematical Programming Study 16 (1982) 84-117.
- 14. Approximate cost of obtaining software:** \$300 academic; \$3000 commercial.
- 15. Restrictions on use:** License agreement required.
- 16. Distributor:** Office of Technology Licensing  
                     105 Encina Hall  
                     Stanford University  
                     Stanford, California 94305      Ph: (415)497-0651
- 17. Original source of software:**  
     **Developer:** Bruce A. Murtagh      Michael A. Saunders  
     **Institution:** University of NSW      Stanford University  
     **Sponsor:** DOE, NSF, ONR, ARO
- 18. For further information contact:**  
     Technical details: Michael Saunders, Dept. of Operations Research,  
                             Stanford University, Stanford, CA 94305. (415)497-1875  
     Distribution: Bill Osborn, Office of Technology Licensing  
                             (see 16 above)

1. **Name of program or package:** TD02
2. **Descriptive title:** Evaluates an approximate Jacobian matrix.
3. **Problem domain:** Must be given a function  $f(x)$ .
4. **Method of solution:** First central differences with an automatic choice of step-size.
5. **Programming language:** IBM Fortran.
6. **Precision:** Both single and double precision versions are available.
7. **Portability:** Fortran 66 version available.
8. **Other packages required:** None.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 237 **Percentage comments:** 18%
12. **Special features:** May or may not be given the sparsity pattern. Uses the sparsity to economize on function calls.
13. **Documentation and references:**  
**Detailed header comments?** No.  
**User guide or manual, technical reports, papers, books:**  
 Harwell Subroutine Library Specification Document.  
 A.R.Curtis, M.J.D.Powell and J.K.Reid (1974) On the estimation of sparse Jacobian matrices.  
 J. Inst. Math. Applics. **13**, 117-120.  
 A.R.Curtis and J.K.Reid (1974) The choice of step lengths when using differences to  
 approximate Jacobian matrices. J. Inst. Math. Applics **13**, 121-126.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell,  
 Oxfordshire OX11 0RA, England.
17. **Original source of software:**  
**Developer:** J.K.Reid.  
**Institution:** A.E.R.E. Harwell.  
**Sponsor:** A.E.R.E. Harwell.
18. **For further information contact:** The developer.

1. **Name of program or package:** TD03
2. **Descriptive title:** Evaluates an approximate Hessian matrix.
3. **Problem domain:** Sparse Hessian matrices.
4. **Method of solution:** Finite differences.
5. **Programming language:** Fortran 66.
6. **Precision:** Double precision.
7. **Portability:** Fortran 66.
8. **Other packages required:** None.
9. **Mode of use:** Subroutine calls.
10. **Test of demonstration program available:** Yes.
11. **Length of code in lines:** 882 **Percentage comments:** 53%
12. **Special features:** Uses sparsity to economize function calls.
13. **Documentation and references:**
  - ☒ **ailed header comments?** Yes, for auxiliary routines.
  - User guide or manual, technical reports, papers, books:**
    - Harwell Subroutine Library Specification Document.
    - M.J.D.Powell and P.L.Toint (1979) On the estimation of sparse Hessian matrices. S.I.A.M. J. Numer. Anal. **16**, 1060-1074.
14. **Approximate cost of obtaining software:** See appendix on Harwell Subroutine Library.
15. **Restrictions on use:** (ii), (iii) (see appendix on Harwell Subroutine Library).
16. **Distributor:** S. Marlow, CSS Division, Building 8.9, A.E.R.E. Harwell, Oxfordshire OX11 0RA, England.
17. **Original source of software:**
  - Developer:** P.L.Toint and I.S.Duff.
  - Institution:** Univ. of Namur and A.E.R.E. Harwell.
  - Sponsor:** Univ. of Namur and A.E.R.E. Harwell.
18. **For further information contact:** I.S.Duff.

- 1. Name of program or package:** DSM
- 2. Descriptive title:** Package for estimating a sparse Jacobian matrix with a minimal or nearly minimal number of function evaluations.
- 3. Problem domain:** DSM partitions the columns of a sparse matrix into groups so that columns in a given group do not have a nonzero in the same row position.
- 4. Method of solution:** The partitioning problem is associated with an equivalent graph coloring problem, and graph coloring heuristics are used to solve the partitioning problem.
- 5. Programming language:** ANSI Fortran 66
- 6. Precision:** Not applicable. Only integer arithmetic used.
- 7. Portability:** Machine independent.
- 8. Other packages required:** None
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 1470                      **Percentage comments:** 67%
- 12. Special features:** DSM is designed to produce optimal or nearly optimal results. DSM is called once to analyze the sparsity structure of the Jacobian matrix. DSM then produces the partitioning information needed to estimate the Jacobian matrix. This information is stored in an integer array of length equal to the number of variables.
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - Coleman, T. F. and Moré, J. J. [1981]. Estimation of sparse Jacobian matrices and graph coloring problems, Argonne National Laboratory, Report ANL-81-39. To appear in SIAM J. Numerical Analysis.
    - Coleman, T. F. and Moré, J. J. [1982]. Software for estimating sparse Jacobian matrices, Argonne National Laboratory, Report ANL-82-37.
- 14. Approximate cost of obtaining software:** Determined by NESC
- 15. Restrictions on use:** None
- 16. Distributor:** National Energy Software Center (NESC)
- 17. Original source of software:**
  - Developer:** Coleman, T. F., Garbow, B. S., and Moré, J. J.
  - Institution:** Argonne National Laboratory
  - Sponsor:** DOE
- 18. For further information contact:**
  - B. S. Garbow
  - Mathematics and Computer Science Division
  - Argonne National Laboratory
  - Argonne, Illinois 60439
  - (312) 972-7184 (FTS):972-7184



1. **Name of program or package:** MFLPP
2. **Descriptive title:** Continuous Minisum Multifacility Location Problem Solver
3. **Problem domain:** Unconstrained  $\ell_p$  distance problems
4. **Method of solution:** Projected Newton Method
5. **Programming language:** ANSI FORTRAN
6. **Precision:** Single
7. **Portability:** Runs through PFORT verifiew
8. **Other packages required:** None
9. **Mode of use:** Callable subroutines
10. **Test or demonstration program available?** Not yet
11. **Length of code in lines:** **Percentage comments:**
12. **Special features:** Ability to handle certain constraints to be added in the near future
13. **Documentation and references:**
  - Detailed header comments?** No
  - User guide or manual, technical reports, papers, books:**
    - Paper: "A Second-order method for solving the continuous multifacility location problem," Paul Calamai and Andrew Conn, Proceedings of the 1981 Dundee Conference in Numerical Analysis (to appear).
14. **Approximate cost of obtaining software:** Mail + tape (research); To be determined (commercial).
15. **Restrictions on use:** None (research);
16. **Distributor:** To be determined (commercial)  
(See 18. )
17. **Original source of software:**
  - Developer:** Paul Calamai and Andrew Conn
  - Institution:** University of Waterloo, Waterloo, Ontario, CANADA
  - Sponsor:** NSERCC
18. **For further information contact:**
  - A. R. Conn, Department of Computer Science
  - P. H. Calamai, Department of Systems Design
  - University of Waterloo
  - Waterloo, Ontario, CANADA N2L 3G1

1. **Name of program or package:** EPO 1
2. **Descriptive title:** Entropy problem solver.
3. **Problem domain:** Maximization of entropy subject to sparse linear equality and inequality constraints. Applications in regional science, traffic planning, etc.
4. **Method of solution:** The Newton - conjugate gradient method.
5. **Programming language:** ANSI FORTRAN
6. **Precision:** Single and double.
7. **Portability:** Developed on DEC 10. Easily portable.
8. **Other packages required:** None.
9. **Mode of use:** Callable subroutine.
10. **Test or demonstration program available?** Yes.
11. **Length of code in lines:** 1200                      **Percentage comments:** 65 %
12. **Special features:** -
13. **Documentation and references:**  
    **Detailed header comments?** Yes.  
    **User guide or manual, technical reports, papers, books:**  
    Jan Eriksson, Algorithms for entropy and mathematical programming,  
    Linköping Studies in Science and Technology Dissertations No.63  
    Linköping University, Sweden.
14. **Approximate cost of obtaining software:** Free for none commercial use.
15. **Restrictions on use:** License agreement required for commercial use.
16. **Distributor:**
17. **Original source of software:**  
    **Developer:** Jan Eriksson  
    **Institution:** Department of Mathematics, Linköping University  
    **Sponsor:**
18. **For further information contact:** Jan Eriksson  
    Department of Mathematics  
    Linköping University, S-581 83 Linköping  
    Sweden. Phone: 46-111700

- 1. Name of program or package:**
- 2. Descriptive title:** Input-Output Model of the World Economy
- 3. Problem domain:** Nonsymmetric sparse bordered block diagonal linear systems in each time period
- 4. Method of solution:** Block Gauss in each system, direct method for each block
- 5. Programming language:** ANSI FORTRAN
- 6. Precision:** Available in single and double precision
- 7. Portability:** Developed on IBM, but only used standard FORTRAN to make it very portable-IBM version with half length integer also available
- 8. Other packages required:** LINPACK, MA28 set from Harwell
- 9. Mode of use:** Driver program and 36 subroutines (18 of which are from the above mentioned packages)
- 10. Test or demonstration program available?**
- 11. Length of code in lines:** 5000 including **Percentage comments:** 40%  
2000 from packages
- 12. Special features:** special "global" storage scheme
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:** (1) World Model Program Documentation-Release 1, July 1982; (2) Daniel B. Szyld-Using Sparse Matrix Techniques to solve a model of the World Economy, in I.S. Duff (ed.) Sparse Matrices and their Uses, Academic Press, London, 1981, pp. 357-365; (3) Faye Duchin and Daniel B. Szyld, Application of Sparse Matrix Techniques to Inter Regional Input-Output Analysis-Economics of Planning, 15 (1979) pp.142-167.
- 14. Approximate cost of obtaining software:** To discuss in each case
- 15. Restrictions on use:** Agreement required
- 16. Distributor:** Same as 18.
- 17. Original source of software:**
  - Developer:** Daniel B. Szyld
  - Institution:** Institute for Economic Analysis, New York University
  - Sponsor:**
- 18. For further information contact:**
  - Daniel B. Szyld
  - Institute for Economic Analysis
  - New York University
  - 269 Mercer Street
  - New York, N.Y. 10003
  - Phone: (212) 598-3413

**1. Name of program or package:** CONOPT

**2. Descriptive title:** Large Scale Optimal Control System

**3. Problem domain:** Time-dependent optimization problems with linear/nonlinear objective, linear/nonlinear constraints, and bounds.

**4. Method of solution:** Reduced gradient - relying on sparsity and staircase structure.

**5. Programming language:** FORTRAN

**6. Precision:** Single and double

**7. Portability:** Developed on CDC. Other versions are being developed.

**8. Other packages required:** none

**9. Mode of use:** Stand-alone job control procedure

**10. Test or demonstration program available?** Yes

**11. Length of code in lines:** 20,000                      **Percentage comments:** 40

**12. Special features:**

**13. Documentation and references:**

**Detailed header comments?**

**User guide or manual, technical reports, papers, books:**

CONOPT - A System for Large Scale Dynamic Nonlinear Optimization, User's Guide,  
Arne Drud and Alex Meeraus, Development Research Center, World  
Bank, 1818 H Street, N.W., Washington, D.C., 20433, U.S.A.

**14. Approximate cost of obtaining software:** negotiable

**15. Restrictions on use:** license agreement required

**16. Distributor:** See 18

**17. Original source of software:**

**Developer:** Arne Drud

**Institution:** Development Research Department, World Bank

**Sponsor:** -

**18. For further information contact:**

Arne Drud  
Development Research Department  
The World Bank  
1818 H Street, N.W.  
Washington, D.C. 20433  
U.S.A.  
Phone - (202) 676-1034

1. **Name of program or package:** NLPNET
2. **Descriptive title:** Large- Scale LINEAR and Nonlinear Network Flow Optimization Solver
3. **Problem domain:** Minimization of separable functions subject to network flow constraints (water distribution, electrical power network optimization, Econometrics)
4. **Method of solution:**
5. **Programming language:** Fortran IV
6. **Precision:** Single or Double
7. **Portability:** CDC, IBM, DEC
8. **Other packages required:** NONE
9. **Mode of use:** Callable subroutine, stand alone main also included
10. **Test or demonstration program available?**
11. **Length of code in lines:** 6,000                      **Percentage comments:** 40%
12. **Special features:** Can take advantage of machines supporting INTEGER \* 2 to reduce storage significantly.
13. **Documentation and references:**
  - Detailed header comments?**
  - User guide or manual, technical reports, papers, books:**
    - User guide, technical reports
14. **Approximate cost of obtaining software:** \$300.00 for research
15. **Restrictions on use:** None (research). Varies for commercial use.
16. **Distributor:** License agreement (commercial).
  - Ron Dembo
  - SOM, Yale University, Box 1A, New Haven, CT 06520 Ph. (203) 436-1952
17. **Original source of software:**
  - Developer:** R. Dembo
  - Institution:** Yale University
  - Sponsor:** (In part) NSF
18. **For further information contact:**
  - Ron Dembo
  - SOM
  - Yale University
  - Box 1A
  - New Haven, CT 06520

- 1. Name of program or package:** FACSIMILE
- 2. Descriptive title:** Simulator for mass action kinetics with diffusion/advection, and other initial value problems.
- 3. Problem domain:** Stiff ODE, including large problems.
- 4. Method of solution:** Backward Difference Formula, with sparse matrix handling by Harwell MA28 package (non-symmetric, minimum degree).
- 5. Programming language:** Written in Fortran 66. Provides user with Problem-Oriented High Level Language.
- 6. Precision:** User-specified. Default  $10^{-3}$ .
- 7. Portability:** Available on IBM, Amdahl, Perkins-Elmer; Cray; ICL 29XX; DEC VAX. Others considered.
- 8. Other packages required:** All included.
- 9. Mode of use:** Background or foreground.
- 10. Test or demonstration program available?** Package of ~ 10 test problems.
- 11. Length of code in lines:** ~ 21,000. **Percentage comments:** Small.
- 12. Special features:** Complete package providing command language and high-level programming language, with powerful input/output features, all in a single job step. Optimisation (parameter-fitting) features.
- 13. Documentation and references:**
  - Detailed header comments?** No.
  - User guide or manual, technical reports, papers, books:**
    - User manual (with updates).
    - Implementation Manual.
    - Reports on applications in certain cases.
- 14. Approximate cost of obtaining software:** \$5,000 for indefinite license.
- 15. Restrictions on use:** Single CPU. Special terms for more than one.
- 16. Distributor:** A.E.R.E. Harwell,  
Didcot,  
Oxon OX11 0RA, England.
- 17. Original source of software:** A.E.R.E. Harwell.  
**Developer:** Applied Mathematics Group, A.E.R.E.  
**Institution:** A.E.R.E.  
**Sponsor:** U.K.A.E.A.
- 18. For further information contact:**
  - (a) A.R. Curtis,  
Computer Science and Systems Division,  
A.E.R.E.
  - (b) Commercial Officer,  
C.S.S.D.  
A.E.R.E.

1. **Name of program or package:** GEARBI
2. **Descriptive title:** Solves initial value problem for ODE system having a blocked sparse Jacobian
3. **Problem domain:** Stiff or nonstiff systems, given in explicit form  $y = f(t,y)$  with regular block structure
4. **Method of solution:** Adams or BDF integration, with block-SOR for linear system solution
5. **Programming language:** FORTRAN IV
6. **Precision:** Single
7. **Portability:** Developed on CDC-7600, but reasonably portable
8. **Other packages required:** None
9. **Mode of use:** Callable subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** appx. 1350      **Percentage comments:** 43%
12. **Special features:** Internal Common blocks require redimensioning for large problems. Relaxing assumptions about block structure requires changes in one routine.
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - A. C. Hindmarsh, "Preliminary Documentation of GEARBI: Solution of ODE Systems with Block-Iterative Treatment of the Jacobian," LLNL Report UCID-30149, December 1976.
14. **Approximate cost of obtaining software:** None
15. **Restrictions on use:** None
16. **Distributor:** Same as 18.
17. **Original source of software:**
  - Developer:** Alan C. Hindmarsh
  - Institution:** LLNL
  - Sponsor:** DOE
18. **For further information contact:**
  - Alan C. Hindmarsh
  - Mathematics and Statistics Division, L-316
  - Lawrence Livermore National Laboratory
  - Livermore, California 94550
  - Phone: (415) 422-4276
  - FTS - 532-4276

1. **Name of program or package:** LSODES
2. **Descriptive title:** Solves initial value problem for ODE system having a general sparse Jacobian
3. **Problem domain:** Stiff or nonstiff systems, given in explicit form  
 $y = f(t, y)$
4. **Method of solution:** Adams or BDF integration, with YSMP (Yale Sparse Matrix Package) for linear system solution
5. **Programming language:** FORTRAN IV
6. **Precision:** Both single and double precision versions (separate) available
7. **Portability:** Developed on CDC-7600 but designed to be highly portable
8. **Other packages required:** [YSMP (ODRV and CDRV) supplied with package]
9. **Mode of use:** Callable subroutine
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** apprx. 5400      **Percentage comments:** 55%
12. **Special features:** Easy to use in dump/restart or overlay mode
13. **Documentation and references:**
  - Detailed header comments?** Yes (this is the only usage manual at present)
  - User guide or manual, technical reports, papers, books:**
    - A. C. Hindmarsh, "Toward a Systematized Collection of ODE Solvers," in the Proceedings of the 10th IMACS World Congress, 1982 (in process).
14. **Approximate cost of obtaining software:** None
15. **Restrictions on use:** None
16. **Distributor:** Same as 18.
17. **Original source of software:** (excluding development of YSMP)
  - Developer:** Alan C. Hindmarsh(LLNL), Andrew H. Sherman (Exxon Prod. Res. Co.)
  - Institution:** LLNL
  - Sponsor:** DOE
18. **For further information contact:**
  - Alan C. Hindmarsh
  - Mathematics and Statistics Division, L-316
  - Lawrence Livermore National Laboratory
  - Livermore, California 94550
  - Phone: (415) 422-4276
  - FTS - 532-4276



- 1. Name of program or package:** LSOD28
- 2. Descriptive title:** Stiff ODE Solver for Sparse Systems
- 3. Problem domain:** Stiff ODE initial value problems with particular application to problems having a general large sparse Jacobian matrix.
- 4. Method of solution:** Gear's backward differentiation formulas. LU decomposition.
- 5. Programming language:** FORTRAN
- 6. Precision:** Single and double precision; standard FORTRAN, IBM FORTRAN using INTEGER\*2 representation.
- 7. Portability:** Developed on IBM; designed to be easily portable
- 8. Other packages required:** Proprietary package MA28
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 3000                      **Percentage comments:** 35%
- 12. Special features:** Option of using INTEGER\*2 representation for integer arrays on IBM machines.
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**

LSOD28: A Variant of LSODE for Problems Having a General Large Sparse Jacobian Matrix by Richard L. Cox, K/CSD-16 (October 1982).
- 14. Approximate cost of obtaining software:** LSOD28, nominal; MA28, \$400
- 15. Restrictions on use:** None on LSOD28; MA28 proprietary.
- 16. Distributor:**

National Energy Software Center	Harwell Subroutine Library
Argonne National Laboratory	Building 8.9
LSOD28: 9700 South Cass Avenue	MA28: AERE Harwell
Argonne, Illinois 60439	Oxon Ox11 ORA
	England
- 17. Original source of software:**
  - Developer:** Richard L. Cox
  - Institution:** Oak Ridge Gaseous Diffusion Plant, Oak Ridge, TN
  - Sponsor:** DOE

**18 For further information contact:**

Richard L. Cox  
 Union Carbide Corporation  
 Nuclear Division  
 P. O. Box P, Bldg. K-1007  
 Oak Ridge, TN 37830

Phone: Commercial 615/574-8726  
 FTS 624-8726

- 1. Name of program or package:** SPARKS
- 2. Descriptive title:** Stiff ODE package
- 3. Problem domain:** Large systems of ODE's with Sparse Jacobians
- 4. Method of solution:** Semi Implicit Runge Kutta method
- 5. Programming language:** FORTRAN
- 6. Precision:** Single IBM-3033
- 7. Portability:** Developed for IBM-3033 but has been transformed to UNIVAC
- 8. Other packages required:** Uses SSLEST for Sparse Matrix Factorization
- 9. Mode of use:** Callable subroutine package includes 5 subroutines
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 1100 lines of code      **Percentage comments:** 25% comments
- 12. Special features:** Uses efficient Jacobian evaluation.  
Applies drop tolerance and iterative refinement.  
Variable stepsize control
- 13. Documentation and references:**  
**Detailed header comments?**  
**User guide or manual, technical reports, papers, books:**  
Users guide: N. Houbak & P.G. Thomsen  
SPARKS - A Fortran subroutine for the solution of Large  
Systems of Stiff ODE;s with Sparse Jacobians. NI-79-02
- 14. Approximate cost of obtaining software:** \$ 50
- 15. Restrictions on use:** Non commercial
- 16. Distributor:** Dept. for Numerical Analysis  
Bulding 303  
Technical University of Denmark, DK-2800 Lyngby, Denmark
- 17. Original source of software:**  
**Developer:** N. Houbak - P.G. Thomsen  
**Institution:** Dept. for Numerical Analysis, Technical Univ. of Denmark  
**Sponsor:**
- 18. For further information contact:** Per Grove Thomsen  
Dept. for Numerical Analysis, Bulding 303  
Technical University of Denmark, DK-2800 Lyngby  
DENMARK, Tel. 881911 ext. 4373

- 1. Name of program or package:** LARKIN
- 2. Descriptive title:** simulation package for large chemical reaction systems
- 3. Problem domain:** solution of very large systems of stiff ODE's arising from chemical kinetics
- 4. Method of solution:** stiff extrapolation integrator using adapted sparse matrix techniques
- 5. Programming language:** standard FORTRAN (ANSI-FORTRAN with few extensions)
- 6. Precision:** either
- 7. Portability:** developed on IBM 370/168, easily portable to other machines
- 8. Other packages required:** none
- 9. Mode of use:** main program with subroutines
- 10. Test or demonstration program available?** yes
- 11. Length of code in lines:** 8300      **Percentage comments:** 35%
- 12. Special features:** segmented for OVERLAY  
package designed especially for interactive use
- 13. Documentation and references:**
  - Detailed header comments?** yes
  - User guide or manual, technical reports, papers, books:**
    - Deuflhard, Bader, Nowak: LARKIN - a software package for the numerical simulation of LARge systems ...; Univ. Heidelberg T.Report 100 (1980)
    - Bader, Nowak, Deuflhard: An advanced simulation package for large chemical reaction systems; Univ. Heidelberg, T.Rep. 149 (1982)
    - Duff, Nowak: On sparse matrix techniques in ...; T.Rep. (1982)
- 14. Approximate cost of obtaining software:** not yet decided
- 15. Restrictions on use:** licence agreement required
- 16. Distributor:** Prof. Dr. P. Deuflhard  
Universität Heidelberg, Institut f. Angewandte Mathematik  
D-6900 Heidelberg, W. Germany
- 17. Original source of software:**
  - Developer:** U. Nowak, G. Bader, P. Deuflhard
  - Institution:** Inst. f. Applied Mathematics, Universität Heidelberg
  - Sponsor:** DFG (SFB 123)
- 18. For further information contact:** Ulrich Nowak  
Universität Heidelberg  
Institut für Angewandte Mathematik  
Im Neuenheimer Feld 293  
D-6900 Heidelberg  
W. Germany

**1. Name of program or package:** GRIDPACK

**2. Descriptive title:** Grid manipulation software

**3. Problem domain:** Problems described on grids, mainly derived from partial differential boundary value problems.

**4. Method of solution:** Any grid-oriented method. (The package is most useful for implementing multigrid solutions, especially for general domains).

**5. Programming language:** Standard FORTRAN only.

**6. Precision:** mixed

**7. Portability:** Software developed on IBM, fully portable. (Machine-dependent constants are fully specified).

**8. Other packages required:** None

**9. Mode of use:** Collection of subroutines

**10. Test or demonstration program available?** Yes.

**11. Length of code in lines:** 20,000      **Percentage comments:** 15%

**12. Special features:** Requires secondary storage for some parts.

**13. Documentation and references:**

**Detailed header comments?** Yes.

**User guide or manual, technical reports, papers, books:** Manual on the same tape. General description in Chapter 4 of: A. Brandt, Multilevel adaptive techniques (MLAT) for partial differential equations: ideas and software, Mathematical Software III (John R. Rice, ed.), Academic Press 1977, pp. 273-314.

**14. Approximate cost of obtaining software:** None.

**15. Restrictions on use:** None.

**16. Distributor:** Department of Applied Mathematics  
The Weizmann Institute of Science  
Rehovot, Israel 76100

Attention: Dr. Dan Ophir

**17. Original source of software:**

**Developer:** Achi Brandt and Dan Ophir.

**Institution:** Weizmann Institute of Science, Rehovot, Israel, 76100.

**Sponsor:** ARO

**18. For further information contact:** Dr. Dan Ophir

Department of Applied Mathematics  
The Weizmann Institute of Science  
Rehovot, Israel 76100

Telephone: (Country code 972) 54-83545  
(Secretary)

- 1. Name of program or package:** KUBIK
- 2. Descriptive title:** Finite and infinite element mesh generator.
- 3. Problem domain:** 2- and 3- dimensional domains of any degree of complexity.
- 4. Method of solution:** Divide and conquer. Sparse matrix techniques are used throughout and a sparse mesh connectivity matrix is provided.
- 5. Programming language:** FORTRAN IV.
- 6. Precision:** Single.
- 7. Portability:** IBM-360; IBM-370; VAX-11; CDC-6600; CDC-7600; XEROX-SIGMA-7.  
Easily portable to other machines.
- 8. Other packages required:** None.
- 9. Mode of use:** A main program calls the subroutines as required by the commands issued by user.
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 4500. **Percentage comments:** 20.
- 12. Special features:** The program is segmented for overlay. Secondary storage is optional.
- 13. Documentation and references:**

**Detailed header comments?** No.

**User guide or manual, technical reports, papers, books:**

  - a. User Manual and Operation Manual are provided with program.
  - b. S. Pissanetzky. Int.J.Num.Meth.Engng. 17, 255-269 (1981).
  - c. S. Pissanetzky. Brookhaven National Lab. Report BNL 27073 (1979).
  - d. S. Pissanetzky. Computer Physics Communications, to appear.
- 14. Approximate cost of obtaining software:** None. Write to liaison officer.
- 15. Restrictions on use:** Only for research purposes.
- 16. Distributor:** Liaison officer is Sergio Pissanetzky, Centro Atómico Bariloche, 8400 - Bariloche, R.N., Argentina.
- 17. Original source of software:**

**Developer:** Sergio Pissanetzky

**Institution:** Comisión Nacional de Energía Atómica.

**Sponsor:** Comisión Nacional de Energía Atómica.
- 18. For further information contact:** Ronald Peierls, Chairman.  
Applied Mathematics Department. Brookhaven National Laboratory.  
Upton, N.Y. 11973, U.S.A.

- 1. Name of program or package:** ELLPACK
- 2. Descriptive title:**  
Solution of Elliptic Problems in 2 and 3 Dimensions
- 3. Problem domain:**  
Linear, Second Order Elliptic PDEs. General domains in 2-D, rectangular domains in 3-D.
- 4. Method of solution:**  
Manifold
- 5. Programming language:**  
Fortran, has own language as Fortran preprocessor
- 6. Precision:**  
Single or double
- 7. Portability:**  
High
- 8. Other packages required:** None
- 9. Mode of use:** Batch
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** 60-80,000  
**Percentage comments:** unknown, but reasonable
- 12. Special features:**  
Included are: 4 YALE PACK sparse matrix programs, ACM Algorithm 533: NSPIV (Sparse Gauss elimination with pivoting), 7 ITPACK iterative method routines and 4 band solvers.
- 13. Documentation and references:** Yes  
**Detailed header comments?** Solving Elliptic Problems with ELLPACK  
**User guide or manual, technical reports, papers, books:** J.R. Rice and R.F. Boisvert, Springer-Verlag, 1983. Several technical reports also available.
- 14. Approximate cost of obtaining software:** \$75 (obsolete version), \$1000 (current version) \$200 to educational inst.
- 15. Restrictions on use:** None
- 16. Distributor:** IMSL (obsolete version), Purdue Univ. (current version)
- 17. Original source of software:** ELLPACK cooperative project  
**Developer:** John R. Rice coordinator, about 20 contributors  
**Institution:** Purdue University  
**Sponsor:** Many
- 18. For further information contact:** John R. Rice  
Math Science 428  
Purdue University  
W. Lafayette, IN 47907  
(317)494-6007

- 1. Name of program or package:** FISHPAK
- 2. Descriptive title:** Efficient FORTRAN subprograms for solving separable elliptic equations
- 3. Problem domain:** Separable elliptic equations subject to standard boundary conditions
- 4. Method of solution:** Cyclic reduction and Fourier analysis
- 5. Programming language:** ANSI FORTRAN
- 6. Precision:** Single
- 7. Portability:** PFORT verified
- 8. Other packages required:** None
- 9. Mode of use:** Subprograms
- 10. Test or demonstration program available?** Yes, included with package
- 11. Length of code in lines:** 20,000      **Percentage comments:** 30%
- 12. Special features:** None

**13. Documentation and references:**

**Detailed header comments?** Yes

**User guide or manual, technical reports, papers, books:**

Algorithm 541, efficient FORTRAN subprograms for the solution of separable elliptic partial differential equations, TOMS, Vol. 5, No. 3, 1979

**14. Approximate cost of obtaining software:** \$300

**15. Restrictions on use:** None

**16. Distributor:** Scientific Computing Division  
National Center for Atmospheric Research  
P.O. Box 3000, Boulder, Colorado 80307

**17. Original source of software:**

**Developer:** Paul N. Swartztrauber and Roland A. Sweet

**Institution:** NCAR

**Sponsor:** NSF

**18. For further information contact:**

To order FISHPAK contact Sue Long, NCAR (303) 494-5151 Ext. 505 or FTS 322-5505. Questions should be directed to authors listed in 17.

Paul N. Swartztrauber: (303) 494-5151, Ext. 605 or FTS 322-5605.

Roland A. Sweet: (301) 921-3395 or FTS 921-3395.

- 1. Name of program or package:** HELM3D
- 2. Descriptive title:** Algorithm for Solving the Helmholtz Equation for the Dirichlet Problem
- 3. Problem domain:** General bounded three-dimensional regions
- 4. Method of solution:** Capacitance matrix
- 5. Programming language:** FORTRAN
- 6. Precision:** Single
- 7. Portability:** Easily portable
- 8. Other packages required:** None
- 9. Mode of use:** Callable subroutine
- 10. Test or demonstration program available?** Yes
- 11. Length of code in lines:** Approx. 1700      **Percentage comments:** 50
- 12. Special features:** None
- 13. Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - "Capacitance matrix methods for the Helmholtz equation on general three dimensional regions", MATH. COMP. 33(1979) 849-879.
    - "Algorithm 572", ACM Transactions on Math. Software, 7(1981) 239-246.
- 14. Approximate cost of obtaining software:** \$50
- 15. Restrictions on use:**
- 16. Distributor:** ACM Algorithms Distribution Service  
IMSL  
Sixth Floor, NBC Building, 7500 Bellaire Blvd  
Houston, Texas 77036
- 17. Original source of software:**
  - Developer:** Dianne P. O'Leary and Olof Widlund
  - Institution:** University of MI      Courant Inst.
  - Sponsor:** NSF, ERDA
- 18. For further information contact:** Dianne P. O'Leary  
Computer Science Department  
University of Maryland  
College Park, MD 20742



1. Name of program or package: HELM
2. Descriptive title: Solution of Helmholtz equation in a general two-dimensional domain
3. Problem domain:  $-u_{xx}-u_{yy}+cu=f(x,y)$  in  $\Omega \subset (0, 1) \times (0,1)$   
 $u(x,y)=g(x,y)$  on  $\Gamma = \partial\Omega$
4. Method of solution: Multi-grid iteration
5. Programming language: FORTRAN
6. Precision: Single
7. Portability: Developed on CDC 72/76
8. Other packages required: None
9. Mode of use: Sequence of subroutines to be called
10. Test or demonstration program available? No
11. Length of code in lines: about 350      Percentage comments: 0%
12. Special features: Arrays on LEVEL 2 used
13. Documentation and references:  
Detailed header comments? No  
User guide or manual, technical reports, papers, books:  
Programme list with some comments in report (German)
14. Approximate cost of obtaining software: Mailing costs
15. Restrictions on use: —
16. Distributor: Same as 18.
17. Original source of software:  
Developer: W. Hackbusch  
Institution: Universität zu Köln  
Sponsor: —
18. For further information contact:  
W. Hackbusch  
Institut für Informatik  
Universität Kiel  
Olshausenstr 40-60  
D-2300 Kiel 1  
Germany

1. **Name of program or package:** RECTCF
2. **Descriptive title:** Solution of elliptic second order problems in a rectangle
3. **Problem domain:** PDE:  $au_{xx} + bu_{xy} + cu_{yy} + du_x + eu_y + fu = g$ ,  $a=a(x,y)$ ,  $b=...$   
Boundary condition: Dirichlet, Neumann, mixed, periodic on rectangle
4. **Method of solution:** Iterative solution by a multi-grid method
5. **Programming language:** FORTRAN (equivalent programme available in ALGOL)
6. **Precision:** Single
7. **Portability:** Developed on CDC 72/76, easily portable
8. **Other packages required:** None
9. **Mode of use:** Sequence of subroutines to be called
10. **Test or demonstration program available?** Report contains test examples with output
11. **Length of code in lines:** about 500      **Percentage comments:** 0%
12. **Special features:** Arrays on LEVEL 2 used
13. **Documentation and references:**  
**Detailed header comments?** None  
**User guide or manual, technical reports, papers, books:**  
 The report "W. Hackbusch: A multi-grid method applied to a boundary value problem with variable coefficients in a rectangle. Report 77-17, 1977" describes the use of the programme and contains test examples.
14. **Approximate cost of obtaining software:** Mail costs
15. **Restrictions on use:** None
16. **Distributor:** Same as 18; or: OECD-NEA Data Bank
17. **Original source of software:**  
**Developer:** W. Hackbusch  
**Institution:** Universität zu Köln  
**Sponsor:**
18. **For further information contact:**  
 W. Hackbusch  
 Institut für Informatik  
 Universität Kiel  
 Olshausenstr. 40-60,  
 D-2300 Kiel 1  
 Germany

**1. Name of program or package:**

IMSL TWODEPEP

**2. Descriptive title:**

Two dimensional partial differential equation solver

**3. Problem domain:**

General elliptic, parabolic and eigenvalue PDE systems in general 2-D regions

**4. Method of solution:**

Finite element method with quadratic, cubic or quartic triangular elements

**5. Programming language:**

FORTRAN

**6. Precision:**

Single and double for 32 bit computers; otherwise single only

**7. Portability:**

Versions tested on IBM, CDC, DEC10, VAX, Data General, Burroughs, Univac, Honeywell, Prime, Siemens and Cray computers

**8. Other packages required:**

**9. Mode of use:** none  
Preprocessor reads input in special simple format

**10. Test or demonstration program available?** Yes**11. Length of code in lines:****Percentage comments:**

---

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**12. Special features:**

Has out of core solution capability using disk storage but also runs efficiently in a virtual memory environment.

**13. Documentation and references:****Detailed header comments?** No**User guide or manual, technical reports, papers, books:**

IMSL TWODEPEP User's Manual (approx. 100 pages)

**14. Approximate cost of obtaining software:** \$1,500/year (\$900 for universities)**15. Restrictions on use:** license agreement**16. Distributor:**

IMSL, Inc.

7500 Bellaire Blvd., 6th floor  
Houston, TX 77036

tele: (713) 772-1927

**17. Original source of software:****Developer:** Granville Sewell**Institution:** IMSL**Sponsor:****18. For further information contact:**

Granville Sewell

IMSL (tele: (713) 772-1927)

1. **Name of program or package:** PDE2D
2. **Descriptive title:** Nonlinear PDE Solver
3. **Problem domain:** Second Order Quasi-linear Homogeneous PDE's in  
Two Space Variables
4. **Method of solution:** Conjugate Gradient, SOR
5. **Programming language:** 1956 ANSI FORTRAN
6. **Precision:** Single
7. **Portability:** Satisfies PFORT Standard of Portability
8. **Other packages required:** None
9. **Mode of use:** Callable Subroutines
10. **Test or demonstration program available?** Yes
11. **Length of code in lines:** 5000                      **Percentage comments:** 70
12. **Special features:** None
13. **Documentation and references:**
  - Detailed header comments?** Yes
  - User guide or manual, technical reports, papers, books:**
    - "A Portable Software Package for Nonlinear Partial Differential Equations" ORNL/CSD-102
14. **Approximate cost of obtaining software:** None
15. **Restrictions on use:** None
16. **Distributor:** Robert Renka, Union Carbide Corporation, Nuclear Division  
P. O. Box X, Building 4500N, D-224  
Oak Ridge, TN 37830, Phone: (615) 576-5139
17. **Original source of software:**
  - Developer:** Robert Renka
  - Institution:** Oak Ridge National Laboratory
  - Sponsor:** DOE
18. **For further information contact:** Robert Renka  
Union Carbide Corporation, Nuclear Division  
P. O. Box X, Building 4500N, D-224  
Oak Ridge, TN 37830  
Phone: (615) 576-5139

## Appendix A

### SPARSE MATRIX 1982: SOFTWARE CATALOG

In conjunction with the Sparse Matrix Symposium to be held at Fairfield Glade, Tennessee on October 25-27, 1982, we are compiling a catalog of sparse matrix software. The purpose of the catalog is to help potential consumers or developers of sparse matrix software determine what software is available and how it can be obtained. All developers of sparse matrix software are invited to submit a one-page description of each program or package for inclusion in the catalog, which will be distributed to attendees at the conference; the catalog will be available to others on request subsequent to the conference. The catalog will include software for solving general sparse problems in the basic areas of linear systems; eigenvalues and least squares; in other general areas where sparse matrix problems are fundamental, such as optimization and differential equations; and in application areas where the use of sparse matrix techniques is critical.

To achieve a consistent format for the reporting of software, we have devised a form to be completed, together with guidelines and sample responses. This form must be completed with a typewriter *using black ribbon*. To further enhance reproduction quality of the catalog, please use only original forms, not copies. If additional forms are needed, please request more originals.

To help in organizing and indexing the catalog, we have also prepared an outline of various sparse-matrix problem categories, printed on the back of the form. Please indicate which category and keywords apply to your software.

Select the single category that most closely describes the problem to be solved by your software and mark the most appropriate keyword on each line when applicable. This selection will determine the placement of your form in the catalog. An index will also be compiled, based on the methods indicated in Item 4 of the form. We have not listed separate keywords for complex matrices in Categories 1 and 2. If your code is for complex matrices, use the equivalent keywords for real matrices (e.g., "symmetric" for "hermitian").

Our goal is to make the software catalog as inclusive as possible. However, we reserve the right to reject a given submission if it appears to make no significant use of sparse matrix techniques. For example, a stiff ODE solver that provides for a sparse Jacobian matrix would be suitable for inclusion, whereas the average general ODE solver probably would not.

Please return the completed forms by July 1, 1982 and direct all correspondence to:

Robert C. Ward  
Union Carbide Corporation Nuclear Division  
P.O. Box Y  
Oak Ridge, TN 37830

## Appendix B

### INSTRUCTIONS AND SAMPLE RESPONSES FOR FORM

- 1. Name of program or package:** One word (typically 6 to 8 characters) name of package or of primary subroutine.
- 2. Descriptive title:** Short phrase such as "Sparse linear system solver" or "Structural analysis package"
- 3. Problem domain:** Specify problem(s) solved in as much generality as is warranted (e.g., unsymmetric linear systems, symmetric positive definite linear systems, reordering equations to minimize storage, etc.) or a specific application such as power network optimization.
- 4. Method of solution:** Brief indication of methods used (e.g., SOR, bandwidth minimization, minimum degree ordering, Lanczos method, orthogonalization, simplex method, branch and bound, etc.)
- 5. Programming language:** FORTRAN, Algol, PL/1, Basic, etc. Be more specific, if desired and appropriate (e.g., ANSI FORTRAN, FORTRAN IV, IBM FORTRAN H, etc.). If any assembly language modules are used, specify machine.
- 6. Precision:** Single, double, both, mixed, etc.
- 7. Portability:** Specify machine(s) on which software was developed and state whether it is easily portable to other machines.
- 8. Other packages required:** BLAS, LINPACK, EISPACK, IMSL, NAG, etc.
- 9. Mode of use:** Callable subroutine, stand-alone main program, etc.
- 10. Test or demonstration program available?** Yes or no
- 11. Length of code in lines:** (Approximate number.) **Percentage comments:** Approximate percentage of lines which are comments.
- 12. Special features:** Does the software utilize any special features of computer architecture or storage, especially in handling very large problems? (e.g., the program permits or requires use of secondary storage, is easily segmented for overlay, is designed for efficiency in a paging environment, takes advantage of pipeline, parallel or array processors, etc.)
- 13. Documentation and references:**  
**Detailed header comments?** Yes, if sufficient to run program on straightforward problem, otherwise no  
**User guide or manual, technical reports, papers, books:** List only items of direct relevance to the use of the code or to the explanation of its theoretical basis.
- 14. Approximate cost of obtaining software:** If fee is not a one-time charge, state time period covered (typically one year).
- 15. Restrictions on use:** None, proprietary, license agreement required, etc.
- 16. Distributor:** List name, address and phone number of agency (e.g., NESC), commercial vendor, developer, etc., from which software may be obtained. Include electronic mail address if software is obtainable via a computer network.
- 17. Original source of software:**  
**Developer:** List principle author(s) of software  
**Institution:** University, laboratory, private company, etc. where software was developed  
**Sponsor:** Funding agency (DOE, NSF, ONR, ARO, AFOSR, etc.), corporation or institution which financed research and development
- 18. For further information contact:** List name, address and phone number of one person, not necessarily a developer, who is willing to answer questions about software. Include FTS or other special communications network number if applicable.

## Appendix C

### CATEGORIES AND KEY WORDS

#### 1. Systems of Linear Equations

real / complex  
nonsymmetric / symmetric indefinite / symmetric positive definite  
general sparse / band or profile oriented  
direct method / iterative method / combined or semi-iterative

#### 2. Eigenvalue Problems

real / complex  
nonsymmetric / symmetric  
standard / generalized / lambda-matrix  
matrix required / only matrix-vector multiply required

#### 3. Least Squares and other Approximations

norm:  $L_1$  /  $L_2$  /  $L_\infty$  / other  
matrix input by user / matrix generated by program from model  
  model: user defined / polynomial / spline / exponential / trigonometric / other  
parameters: linear / separable / nonlinear  
method: exchange / lp / elimination / orthogonalization / other

#### 4. Optimization

Mathematical programming:  
  objective: linear / separable / sum of squares / quadratic / nonlinear  
  constraints: none / bounds / linear / nonlinear  
Combinatorial optimization and graph algorithms:  
  integer programming / network flow / shortest path /  
  minimal spanning tree / strongly connected components / other

#### 5. Differential Equations

ODE / PDE  
finite differences / finite elements  
time dependent / time independent  
initial value problems / boundary value problems / both / mixed

#### 6. Applications

structural analysis  
electric power systems  
image enhancement and reconstruction  
petroleum and mineral prospecting and recovery  
economic, energy and environmental modeling  
statistical analysis  
control theory and sensitivity analysis  
other (specify):

## Appendix D

### The Harwell Subroutine Library

We wish the subroutine library to be of use to many people and we are willing to provide copies in source code of individual routines or of the whole library to external users on request. Charges are made (see below) to external users to cover the cost of handling, postage and documentation involved in fulfilling their requests for copies.

The charges cover only the copying and despatching of library routines. Therefore we do not undertake to provide any assistance that may be needed to use a subroutine successfully, and we do not guarantee the efficacy of any subroutine or documentation. However we hope that deficiencies in subroutines and the documentation will be brought to our attention, in order that we can improve the library.

Except for a small number of subroutines obtained from elsewhere, the subroutines in the Harwell Subroutine Library are the property of the United Kingdom Atomic Energy Authority and a potential user must accept and abide by the conditions listed below. All communication with the library by external users should be made through Mr.S.Marlow, Building 8.9, AERE Harwell, Didcot, Oxon, OX11 0RA, England. (Tel. Abingdon 24141 ext. 2930), who is the liaison officer for the library's external affairs.

**The conditions** attached to external use are as follows:

- (i) the subroutines may only be used for research purposes by the person or organisation to whom they are supplied. They may not be copied for use by other persons or organisations, except with the written permission of the liaison officer.
- (ii) due acknowledgement is made of the use of subroutines in any research publications resulting from their use.
- (iii) the subroutines may be modified for use in research applications by external users. The nature of such modifications should be indicated in writing for information to the liaison officer. At no time however, shall the subroutines or modifications thereof become the property of the external user.
- (iv) the use of the subroutines in commercial applications must be agreed in writing with AERE Harwell and on terms and conditions to be negotiated. In the first instance, anyone considering such commercial applications should write to the liaison officer.

Conditions (i) and (iv) will be waived for most subroutines dating from before January 1977 and for some more recent ones. The conditions are listed under the subroutine entries in the current version of the catalogue.

**The charges** for library material are listed below. Overseas customers are charged on a different scale than that used for U.K. customers to cover the extra costs in meeting their requirements and all items are despatched by air mail. Charges to customers in the United Kingdom are subject to VAT. All prices given are valid to the 31st December 1982, and subject to review thereafter.

- (1) Listings of subroutines
 

U.K.(excluding VAT)	£7 each
Overseas	£14 each
- (2) Card decks of subroutines
 

U.K.(excluding VAT)	£7 per 400 cards ( <i>minimum order £14</i> )
Overseas	£21 per 400 cards ( <i>minimum order £42</i> )
- (3) Subroutines on magnetic tape (including the cost of the tape which we supply)
 

U.K.(excluding VAT)	£30 for the first two subroutines plus £2 for each subroutine in excess of two.
Overseas	£50 for the first two subroutines plus £2 for each subroutine in excess of two.
- (4) Complete library on tape (including the cost of the tape which we supply and one set of specification sheets)
 

U.K.(excluding VAT)	£120
Overseas	£200
- (5) Additional complete sets of specification sheets
 

U.K.(excluding VAT)	£30 each set
Overseas	£45 each set



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